A FORMATIVE EVALUATION OF GRIFFIN HIGH SCHOOL INTEGRATIVE SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS ACADEMY

by

EZRA MICHAEL THOMPSON

(Under the Direction of Robert C. Wicklein)

ABSTRACT

The objective of this study was to conduct a formative program evaluation in order to identify areas that need improvement in an integrative science, technology, engineering, and mathematics (STEM) education program. STEM disciplines have been historically linked to the status of a nation through the way the people live and work, and the power of the economy. In recent years, education systems across the country have been responding to calls from the U.S. government to increase and expand STEM literacy to all students. There is widespread effort among policymakers, industry leaders, and educators to improve the quality of STEM education at the K–12 level and to increase the number of students who are interested in those disciplines. Schools are motivated to develop quality STEM programs. This study of the integrative STEM Academy at Griffin High School in the Spalding County School District in the state of Georgia evaluated activities and processes of the implementation of the STEM program. Data regarding the program outcomes were collected and analyzed to identify discrepancies in areas that are of concern and to determine changes that will be necessary to improve the efficiency of the STEM Academy instructional practices.

INDEX WORDS: STEM, Integrative STEM education, STEM goals, Formative evaluation, Discrepancy Model, Engagement, Capacity, Continuity, Outcomes

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DEDICATION

I would like to dedicate this dissertation to my family: to my wife, Bridget, and my children, Kevin, Kara, and Kaye. I would also like to dedicate this to the memory of my parents, Daniel and Murdelyn Thompson. To my parents-in-law, Fitz and Valda Lewin; to my brother, Bentley Thompson, and my sisters, Ruth Kelly and Judith Blake; to all my friends and colleagues, I appreciate you for all the influence and inspiration you had on my life.

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INTRODUCTION

STEM is an acronym that stands for the academic disciplines of science, technology, engineering, and mathematics. The National Science Foundation (NSF) began the approach of integrating science, technology, engineering, and mathematics that created the acronym. The acronym embodies the necessary integration of the subject areas necessary to achieve success. STEM education is highly esteemed in relation to the nation's top priorities and boasts wide support from all levels of the U.S. government. STEM concepts are also being embraced in the education community. However, the term has not been clarified as to what it might mean in practice beyond its general label (Bybee, 2010).

Bybee (2010) explained that science deals with and seeks to understand the natural world and serves as the underpinning of technology. With an understanding of science, technology is used as a modification of the natural world in order to meet humans' needs and wants. Engineering is knowledge of mathematics and science gained through study and experience, while applying practice judiciously to develop ways to use materials and the forces of nature in the most efficient manner for the benefit of mankind (International Technology and Engineering Educators Association [ITEEA], 2003). Mathematics is the study of relationships and patterns that provides a precise language for communication in science, technology, and engineering (American Association for the Advancement of Science [AAAS], 1993).

STEM education is an interdisciplinary combination of science, technology, engineering, and mathematics that creates new knowledge (Katsioloudis & Moye, 2012; Lantz, 2009). By bridging these discrete disciplines, this combination of disciplines helped to form a new entity that is now labeled as STEM (Lantz, 2009). According to Lantz (2009), STEM education is described as education that offers students one of the best opportunities to make sense of the world holistically, rather than in isolation. The traditional barriers that have been erected between the four disciplines are being removed with the advent of STEM education, which integrates them into one cohesive teaching and learning paradigm. *STEM education* is defined as a standards-based, multidiscipline approach that offers the opportunities for science, technology, engineering, and mathematics teachers to take an integrated approach to teaching and learning, where discipline-specific contents are undivided, and addressed and treated as one dynamic fluid study (Brown, Brown, Reardon, & Merrill, 2011).

Additionally, STEM education is viewed as learning that will provide individuals with the knowledge and skills necessary to meet the demands of the 21st-century work force to ensure the United States remains competitive in the global market place (National Center for Literacy Education, 2012; NSF, 2010). A STEM work force must be strong in order to support new innovations and competitiveness in the global marketplace. STEM education is founded on broad national goals backed by the U.S. government, which embraced STEM as a vital link with an overall national interest. STEM goals are designed so that the outcomes will increase America’s global competitiveness in science and technological innovations and help to guide the implementation of programs designed to increase STEM learning (Hanover Research, 2011).

Getting students interested in the career fields of science, technology, engineering, and mathematics is one of the greatest educational challenges facing the United States today (Becker & Park, 2011). Studies have shown that a substantial number of students leave the STEM pipeline before completing instructional programs, consequently negatively impacting the current and future workforce demand for STEM skills (ACT, 2006; Business-Higher Education Forum, 2010; Bybee, 2010). Political actions have resulted in Congress appropriating several billion dollars to increase the competitiveness of STEM education in the United States (Bybee, 2010) through a variety of programs. Congress and the Obama administration have continued to address the growing concerns regarding STEM. During the 2012 general election, there was political rhetoric regarding the need to increase the investments necessary so there will be more successful STEM programs for students who graduate from high schools and universities with the appropriate knowledge and skills needed for the 21st-century work force (College of Health, Education, and Human Development, 2013; U.S. Department of Energy, 2013; Wells, 2013).

Integrative STEM Education

Integrative STEM education is defined as any program in which there is an explicit assimilation of concepts and practices from more than one of the STEM disciplines (Satchwell & Loepp, 2002). *Integrative STEM education* is a name that was intentionally chosen to capture more of the educational philosophy than the label of *STEM education*. A purposefully formulated operational definition was decided on by Sanders and Wells (2006), who defined *integrative STEM education* as "a technological/engineering design-based learning approach that intentionally integrates the concepts and practices of science and/or mathematics education with the concepts, practices of technology and engineering education" (p. 1). Additionally, integrative STEM education may be enhanced through further integration with other school subjects, such as language arts, social studies, art, and so forth (Sanders & Wells, 2006).

Wells (2013) recently modified the definition of *integrative STEM education*:

> The application of technological/engineering design based pedagogical approaches to intentionally teach content and practices of science and mathematics education concurrently with content and practices of technology/engineering education. Integrative

> STEM education is equally applicable at the natural intersections of learning within the continuum of content areas, educational environments, and academic levels. (p. 28)

According to Sanders (2012), the use of the term *integrative STEM education* does not guarantee best practices in STEM programs but rather should be guided by standards and rely more on the evidence that can be obtained through evaluation or research processes. Furthermore, it is important that integrative STEM education programs be focused on the concepts and practices of the STEM disciplines, as determined by the standards and objectives that have been integrated. There are different ways that schools or classes can approach improving mathematics and science education integration, but too often educators address the topics separately from other subjects (Sanders, 2012).

According to the STEM Education Coalition (2013), the effectiveness of integrative STEM teaching practices can only be addressed in the context of the purposes or goals that are being measured. If schools implement STEM programs, the goals should be clearly specified, with adequate time and resources to accomplish and measure those goals. Whether it is to increase students' knowledge and skills or to attract minority groups that are underrepresented within STEM fields, these goals must be clearly stated before the program is implemented. The need exists to capture and reflect on the types of knowledge and skills needed for the nation's growth and development in an increasingly science- and technology-driven world (Lantz, 2009; Sanders, 2012).

A complete transformation in practice is necessary for integrative STEM education to be successful. Professional development needs to take place for veteran teachers and teacher training programs need to be improved for new teachers that will help educators to think outside the box (Wells, 2013). New resources for activities and delivery of instruction should be considered in relation to the diverse needs of students, who ultimately may pursue advanced degrees and careers in STEM fields, and to broaden the participation of women and minorities in those fields. These practices would be effective in expanding the STEM-capable and diverse work force, thereby increasing STEM literacy for all students in America (Wells, 2013).

Implementing integrative STEM programs involves making changes in practice, which means that various aspects of the traditional education system, such as assessments, scheduling, class size, and curriculum, will be impacted according to the degree of integration (Becker & Park, 2011). How will the implementation of integrative STEM programs affect preparation for student yearly or end-of-course assessments that are necessary for promotion and admission into college? The scheduling practice of classes is usually done in silos. Changes to accommodate integrative STEM education will require school administrative and staff buy-in to achieve the changes necessary for successful integrative STEM programs (Becker & Park, 2011).

The teaching of integrative STEM that involves teachers in more than one discipline takes into consideration impacts on class size, resources for activities, curriculum materials, and delivery methods. Educational practices that are rooted in years of training and experience take valuable time and resources to develop. There are no easy quick fixes to change teaching practices that will guarantee student success. According to Bybee (2010), STEM educators must adhere to sound criteria that are research-based as a guide for the tasks of developing and monitoring new program practices that are necessary for successful integrative STEM education. Despite the challenges for developing effective integrative STEM programs, preliminary results from ongoing studies are encouraging (National Research Council [NRC], 2011).

Experts have suggested that integrative STEM education presents a more relevant approach for educators to expand and increase STEM learning for all students (Sanders, 2012; Satchwell & Loepp, 2002). An integrative STEM program aims to offer a rigorous curriculum that deepens STEM learning over time through project- and inquiry-based learning, more instructional time that is devoted to STEM, more resources available to teach STEM, and teachers who are more prepared to teach in the STEM disciplines (NRC, 2011). Through integrative STEM practices, concepts that are in the National Standards for science, technology, engineering, and mathematics are exercised in unison, allowing students to make connections across disciplines (ITEEA, 2000). Current literature suggests that more research and resources are necessary to fully establish the right platform for best practices that will lead to successful educational outcomes (NRC, 2011; Sanders, 2012).

Integrative STEM Initiative

Integrative STEM programs have been credited for successes cited in some of the United States' most successful STEM schools and programs (NRC, 2011). Primarily, Texas has developed and followed a comprehensive integrative blueprint for its High School Project STEM initiatives. It is believed that the Texas Science, Technology, Engineering, and Mathematics (T-STEM) academies' design is a platform that is helping more students not only in the state of Texas but also nationally to thrive in the 21st-century economy by studying and entering into STEM fields (Communities Foundation of Texas, 2013). Integrative STEM programs have been credited for successful outcomes that are reflecting increases in mathematics and science test scores in T-STEM schools. The T-STEM initiative aims to closely align high school curriculum with admission requirements of competitive colleges and the STEM qualifications for 21st-century jobs. Benchmarks provide formative and comprehensive evaluations that will monitor the STEM program on a path to improvement beginning with the developmental stage and moving to its full maturity within five years. The T-STEM Academy integrative initiative is fully funded through public and private funds and may serve as a model for STEM initiatives for other states or any local school system (Communities Foundation of Texas, 2013).

Criteria for Successful STEM Education

Because there are differing perceptions of successful STEM learning and practices, educators must rely on the findings of research. Research provides assessment mechanisms to monitor the development of STEM initiatives that are being undertaken (Bybee, 2010). Therefore, the design and implementation of successful K–12 STEM education programs will need to have not only a respected STEM curriculum (integrative or other) and established goals but also an approach that will guide the implementation of the STEM education program (Rockwell & Bennett, 2004). This approach will take into consideration the differences between the outcomes or findings of the program and criteria that have been established for successful STEM education programs.

Jolly, Campbell, and Perlman (2004) reviewed several studies on students' successes in STEM disciplines and identified a pattern of three broad-based themes that emerged as factors for success in STEM disciplines—engagement, capacity, and continuity commonly referred to as the ECC trilogy. The trilogy are three characteristics that broadly reflect the nature of successful STEM Education programs. For example, engagement refers to interest, motivation, attitude, etc.; capacity refers to achievement, knowledge, skills; and continuity refers to support system such as access to extracurricular activities, dual enrollment, SAT/ACT, mentorship, etc.

Engagement

Engagement is described as the degree to which students are motivated to participate in school curriculum and other school learning activities (Jolly et al., 2004). Engagement plays an important role in students' educational success and the likelihood of preventing school dropout

(Finn, Pannozzo, & Voelkl, 1995). Engagement can be divided into three components: behavioral, emotional, and cognitive. The behavioral engagement component involves positive conduct toward academic success. The emotional engagement component deals with students' reactions to the educational setting and the environment or the people who are involved in the STEM program. The emotional engagement component also incorporates students' affective reactions in the classroom, including interest and boredom. The cognitive engagement component deals with the commitment and willingness to understand complex concepts related to the learning goals (Fredricks, Blumenfeld, & Paris, 2004; Jolly et al., 2004).

Capacity

Capacity is the degree to which knowledge and skills needed to advance increasingly rigorous content in STEM disciplines are acquired (Jolly et al., 2004). Building STEM knowledge will not happen in a vacuum or without first having the appropriate level of engagement and follow-up opportunities. Capacity will require the building of STEM knowledge to transform technological literacy and meet the demands of today's work force (National Center for Literacy Education, 2012). Studies have suggested there are several factors that can significantly increase STEM learning (Business-Higher Education Forum, 2010; Jolly et al., 2004; Lau & Yuen, 2009; National Center for Literacy Education, 2012; Trochim, 2006; Verma, Dickerson, & McKinney, 2011). The NRC (2011) concluded that integrative STEM curriculum involving project- and problem-based activities serves as a catalyst for increasing STEM knowledge. Studies have also suggested that quality teacher training and professional development programs will significantly impact STEM knowledge of students (Education Resources Institute, 2004; Feller, 2011; National Science Teachers Association, 2006; Wells, 2013).

Continuity

Continuity is a course or pathway that is provided for students to advance to the next level (Jolly et al., 2004). Access to opportunity for advancement in STEM disciplines is the key factor to continuity into postsecondary STEM discipline training and/or the STEM work force. Even after engagement and capacity factors are fully satisfied, continuity is necessary for students to make it through the STEM pipeline. Additionally, access to opportunity for advancement in STEM disciplines leads to further engagement and increased capacity (W. L. Sanders & Rivers, 1996). According to the ECC trilogy model, the Griffin High School integrative STEM Academy must provide enrichment and opportunities for students to continue their interest in STEM beyond the high school level (Felix, Bandstra, & Strosnider, 2010; Jolly et al., 2004). Jolly et al. (2004) suggested that continuity can be improved by providing opportunities for students to participate in STEM-related extracurricular activities; taking advanced-level STEM courses; dual enrollment; taking the ACT/SAT; having access to professionals within a specific field; or any other opportunities, material resources, and guidance that support advancement to increasingly rigorous content in STEM disciplines.

The ECC trilogy (Jolly et al., 2004) is a new theory originally used to frame evaluation designs that contribute to the knowledge base regarding what improvements are necessary to ensure students' continued success in STEM disciplines. The development of successful STEM programs falls into one of these themes. The underlying assumptions of engagement, capacity, and continuity are based on common trends that show the three factors operate interdependently and are required for student success in STEM fields. Therefore, any criteria that will be used to develop an effective and successful integrative STEM Academy will be based on the trilogy factors. The degree to which the three factors are present in the integrative STEM Academy will reflect the Academy's effectiveness and success. The criteria are as follows:

1. STEM programs must provide engagement in STEM disciplines for participating students,
2. STEM programs must increase capacity in STEM disciplines for participating students, and
3. STEM programs must provide continuity in STEM disciplines for participating students (Jolly et al., 2004).

To capture the right perspectives on what successful K–12 STEM education should be, local schools can follow those criteria that are essential for their STEM programs (NRC, 2011). Thus, these criteria will help to guide development of the Griffin High School Integrative STEM Academy. Successful integrative STEM education practices can be identified and classified into three main criteria (NRC, 2011). These criteria are related to STEM outcomes represented by the ECC trilogy (Jolly et al., 2004).

The NRC (2011) provided a framework for successful K–12 STEM programs that was based on extensive research, which provided support for the STEM criteria. This framework is designed for the purpose of accomplishing three broad goals central to practices of STEM disciplines that are essential for student learning. The framework, based on research and available data, shows that outcomes of schools are linked to the success of their educational practices. The NRC study identified several types of STEM schools across the nation that reflected high levels of student engagement, capacity, and continuity in the outcomes. For example, students have high standardized tests scores in STEM disciplines that met the criterion on capacity; students were engaged in extracurricular STEM activities and took advantage of dual-enrollment opportunities.

Students’ achievement tests are commonly used by educators to inform teaching decisions, and could be used to help ascertain which outcomes help determine effective STEM education practices. Test scores, however, do not tell the whole story of success in any given educational program (NRC, 2011). There may be no significant difference between students who participate in an integrative STEM program and students who do not. However, students who participate in integrative STEM programs may have more engagement characteristics or support opportunities and are more likely to make it through the STEM pipeline. Student engagement may be the driving force that results in getting more students into advanced degrees in STEM education programs in comparison to other schools that do not offer the programs. If the instruction is based on an integrative STEM design, test scores alone might not indicate the true outcome due to the influence of instruction (NRC, 2011).

In this study, the STEM criteria were compared with the outcome information obtained from the Griffin High School integrative STEM program to help identify discrepancies in the implementation of the program. Alignment with the national standards for STEM disciplines in science, mathematics, and engineering, and technology (ITEEA, 2000) is central to the development of the Griffin High School integrative STEM program. The need for an effective STEM integration program at Griffin High School is underscored by the fact that there is implementation of a STEM program at the feeder middle schools for Griffin High School from the sixth- up to the ninth-grade level through a program titled the Advanced Manufacturing and Prototyping Integrated to Unlock Potential (AMP-IT-UP) in the Griffin-Spalding County School

System. Therefore, an effective implementation of an integrative STEM Academy is necessary to extend STEM learning in Grades 10–12 at Griffin High School.

Discrepancy Model Approach for Evaluating Integrative STEM

In a planning meeting with stakeholders on April 3, 2013, at Griffin High School, three evaluation models were discussed. It was decided that the discrepancy model approach for program evaluation would be the most suitable format to conduct this evaluation to allow stakeholders to make the improvements in STEM learning at Griffin High School. The discrepancy model assesses whether there is a significant difference between outcomes (i.e., certain findings that are indicators of the level of success) from the STEM academy and the outcomes obtained generally from highly successful STEM programs (McKenna, 1981). The difference between findings STEM academy, based on established STEM criteria and generally the findings of highly successful STEM programs across the nation that determines the effectiveness of the Griffin High School Academy and if any changes needed to be made. If the academy reflects a high degree of engagement, capacity, and continuity outcomes, it means the discrepancies are relatively small and the Academy is more consistent with national STEM programs that are highly successful. This will help the Griffin High School Integrative STEM Academy to be measured against highly successful national STEM schools and programs and to develop a STEM Academy that possesses nationally recognized STEM qualities. The evaluation plan involved gathering academy-related information that could be analyzed and compared to STEM criteria. Identified differences reflected improvements that can be made to further develop the program's effectiveness and to inform decision makers about future changes.

The discrepancy model approach identified differences between what was happening in the Griffin High School Integrative STEM Academy and where the program should be compared to the research-based STEM criteria and data of successful STEM programs across the country (NRC, 2011). Using the discrepancy model approach, areas of concern were identified by comparing program performance (i.e., outcomes such as academic achievement) in STEM disciplines with nationally established criteria that are based on academic standards. Discrepancies can occur after initial program implementations and are identified when comparisons are made to the established national standards (McKenna, 1981). The program evaluation was designed to collect information about the Griffin High School integrative STEM program outcomes in order to understand the successes and shortcomings of the program.

Integrative STEM Curriculum

Integrative STEM education and instructional practices are being explored and have provided opportunities for making STEM learning more concrete and relevant to students (NRC, 2011). The potential value of integrative STEM education is a new concept through blending of curriculum designs that includes an alignment of the Standards for Technological Literacy (developed by the ITEEA), Principles and Standards for School Mathematics (developed by the National Council of Teachers of Mathematics [NCTM]), and Benchmarks for Science Literacy (developed by the AAAS; ITEEA, 2011). Research has shown that the engineering discipline is often integrated into the curriculum of K–12 STEM disciplines (Lantz, 2009). A recent study of active curriculum efforts in the United States revealed that engineering skills and knowledge were identified in 41 states' standards, and that most items rated as engineering through strict coding were found in either science or technology and vocational standards. In addition, engineering was found in only one state's math standard and some states explicitly mentioned engineering standards without any specifics (Carr, Bennett, & Strobel, 2012).

More integrative STEM education programs and K–12 curriculum resources are steadily becoming available. Some, for example, are sponsored through joint efforts of professional organizations within STEM disciplines, state departments of education, and commercial educational enterprises (NRC, 2011). This is consistent with an increasing number of integrative STEM curricula that states and school systems are adopting. For example, the ITEEA developed a standards-based national model for Grades K–12 that is known as the engineering by design (EBD) model. This model is built on the Standards for Technological Literacy (developed by the ITEEA), Principles and Standards for School Mathematics (developed by the NCTM), Project 2061, and Benchmarks for Science Literacy (developed by the AAAS; ITEEA, 2011). According to the ITEEA (2011), there is support from state education departments and school districts for schools to deliver STEM literacy through the EBD curriculum model, which is now in its fourth year in over 350 participating schools nationwide and a consortium of 18 states, including the state of Georgia.

Project Lead the Way (PLTW) is another integrative STEM-based curriculum that is a hands-on activities-, project-, and problem-based comprehensive curriculum aligned with relevant national standards and collaboratively developed and updated by subject matter experts, including teachers, university educators, engineering and biomedical professionals, and school administrators (Tai, 2012). PLTW’s programs emphasize critical thinking, creativity, innovation, and real-world problem-solving experiences. The hands-on learning engages students on multiple levels, exposes them to areas of study they may not otherwise pursue, and provides them with a foundation and proven path to postsecondary training and career success in STEM-related fields.

According to Stohlmann, Moore, and Roehrig (2012), curriculum such as PLTW and EBD are opening the doors for more effective strategies of teaching STEM disciplines. The development of integrative curriculum may increase advanced training and careers in STEM fields, expand the STEM-capable work force, and increase scientific literacy among the general public. Integrative curriculum places emphasis on practices that engage students in integrative STEM learning, across the curriculum, with problem-based inquiry and cross-disciplinary analysis, and is gaining support from communities, businesses, and industries (National Science Board, 2007) whose partnerships with schools are mutually necessary.

Integrative STEM Academy Implementation at Griffin High School

The focus of this study was a newly implemented integrative STEM Academy. Schools across the nation are making the effort to develop effective STEM education programs in order to accomplish successful STEM learning outcomes. For this reason, Griffin High School in Georgia began the implementation of an integrative STEM Academy. The implementation of the integrative STEM Academy began in August of the 2012–2013 school year. Gaining support from the school administrative team and interest of students that emerged from a survey conducted at the school, three teachers met for three days over the summer break in 2012 to align their individual curriculum standards. A sample of the aligned activities is listed in Table 1.

The integrative STEM Academy at Griffin High School has the characteristics of a typical inclusive STEM school that focuses on STEM disciplines with no admissions criteria. Any student in the broader school population can gain access to opportunities presented by the Academy to develop STEM competencies. STEM disciplines are taught in a coordinated effort by teachers following the state’s performance standards for STEM disciplines. The STEM Academy offers college prep classes with a focus on science-, technology-, engineering-, and mathematics-related careers. The potential impact is that students will have a rigorous, relevant, and real-world STEM education.

Table 1

Excerpts of STEM Curriculum Outline for the 2012–2013 School Year

Time	Start date	Engineering teacher	Math teacher	Science teacher
3–3.5 weeks	Sep. 24	Design process/problem-solving activity	Exponential equations/interest rate	Nuclear reactions – fission and fusion
3 weeks	Jan. 7	Aerodynamics	Triangles/right triangles trig.	Distance, displacement, motion
6 weeks	Mar. 4	Electronics, trainers, and simulations	Quadratics and complex numbers	Power and machines Electricity and magnets

Note. The Griffin High School integrative STEM curriculum is comprised of topics in engineering and technology, mathematics, and science with similar themes that are taught simultaneously using problem-/project-based activities.

In the Griffin High School integrative STEM program, students are able to receive instruction in mathematics concepts that are related to the concepts they are learning in science and, simultaneously, to problems they are solving in engineering and technology classes. Students were selected into the integrative STEM cohort by their teachers following a screening process using a STEM interest survey. In this new paradigm, there is an alignment of curriculum standards in the disciplines of mathematics, science, and engineering, and technology. Three teachers (in mathematics, science, and engineering and technology) were assigned to teach group of 60 students using this integrative STEM curriculum.

In a meeting with the staff of Griffin High School Integrative STEM Academy, held on February 8, 2013, the teachers were able to reflect on their planning experiences. One of the things that emerged from the meeting was that the goals of the program were still in the developmental stage. There was an overall need for documentation to support what the STEM teacher team has been doing.

The STEM team talked candidly about their concerns and experiences for the implementation of the integrative STEM academy. They stated that the program's goal is that students will make connections between STEM disciplines and careers that are available in STEM fields. They described some examples of students making connections, but no clearly defined goals or objectives were outlined for implementing the program. To rectify this problem, the staff created a weekly alignment of their curricula to enable them to share what they are doing well and to share gained experiences. Gender diversity but no ethnic and racial diversity was evident among the staff. Furthermore, the staff noted that among the students in the STEM Academy, there is relatively little reflection of the ethnic and racial makeup or equal representation of women when compared to the overall student population of Griffin High School. For example, out of 60 students in the program, only two are African American girls; there are five female students in the entire program. This presents a huge discrepancy given that a large number of students from minority groups attend Griffin High School. Thus, there was a need to examine and include the demographic data of Griffin High School as part of the evaluation.

During the initial planning meeting with stakeholders, which included the principal, integrative STEM educators from Griffin High School, and the University of Georgia team that included two professors and two graduate students, it was also revealed that the staff had made efforts to create an integrated STEM curriculum by aligning standards in individual STEM disciplines and were seeking ways to address concerns for the sustainability of the program. The integrative STEM team was concerned about what the criteria are for successful integrative STEM programs, despite visitations to other programs that claim the integrative STEM status.

Griffin High School students are being positioned to reap the potential value of K–12 integrative STEM education programs that are the focus of an ongoing study for best practices to accomplish successful STEM learning (Hanover Research, 2011; NRC, 2011). All appropriate measures will be taken to address STEM concerns for improvement in the integrative STEM Academy so that important curriculum components and successful developments are not overlooked (Lantz, 2009). There is a clear understanding that progress will not be immediate and that it is not easy to determine what the outcomes for STEM learning really entail. However, there are criteria that are based on some of the nation's highly successful STEM schools and programs (NRC, 2011) that will be considered in the design and implementation of the Griffin High School integrative STEM Academy.

Rationale

The rationale of this study was based on the need to increase the interest and performance of students in STEM disciplines and careers. Stohlmann et al. (2012) noted that integrated STEM education helps to motivate students toward careers in STEM fields and may improve their interest and performance in mathematics and science. The researchers concluded that future research is needed that will continue to focus on the development of curriculum materials and instructional models for STEM integration, teacher training, common planning programs, and classroom teaching practices.

The NRC released a framework in 2011 for successful implementation of a K–12 STEM education. The framework report identified effective approaches in STEM and highlighted effective programs and practices across the country that are linked to successful program outcomes (e.g., test scores, advanced placement [AP] courses taken, etc.). Conversely, researchers have identified several factors (e.g., socioeconomic status, race/ethnicity, gender, environmental support) that are currently affecting student learning in STEM fields (Chadwick, 2011; Forssen, Lauriski-Karriker, Harriger, & Moskal, 2011; Heilbronner, 2009; Milgram, 2011; Pfeiffer, Overstreet, & Park, 2010; Riegle-Crumb, Moore, & Ramos-Wada, 2011).

The ECC trilogy factors are important when studying effects of STEM learning on careers among young adults, and served as the variables for this study. Several STEM-related studies have shown outcomes in which there is a widespread lack of engagement and low level of student achievement in the 21st century, when the demand for STEM skills is increasingly high (Bouvier & Connors, 2011; Business-Higher Education Forum, 2011; Carnevale et al., 2011). According to the National Center for Literacy Education (2012), there are gaps in the success of students in STEM disciplines among different groups; for example, Whites do much better than minorities. Minorities are also largely underrepresented in STEM fields in the work force. This deficiency begins to widen for various reasons as students continue to progress through the STEM pipeline from high school to the work force (Bouvier & Connors, 2011; Bybee, 2010; Iowa STEM Education Roadmap, 2011; U.S. Commission on Civil Rights, 2010).

The central tenet for STEM education is to help prepare students for successful careers and provide the skills needed to meet the demands of a new STEM work force to enable the United States to remain competitive in the global marketplace (Hanover Research, 2011). A positive and clear descriptor of student outcomes related to this central tenet is needed at every stage as students pass through the STEM pipeline (Heilbronner, 2009; Herzog, 2010; Kuenzi, 2008; Lantz, 2009; Pender, Marcotte, Sto. Domingo, & Maton, 2010; Tyler-Wood, Knezek, & Christensen, 2010). In addition, researchers have found that support for development of the STEM educational environment is an influential factor for student success and one of the most important requirements necessary to improve diversity in the STEM work force (Gordon, 2010;

Hayden, Ouyang, Scinski, Olszewski, & Bielefeldt, 2011). For example, effort to increase the STEM learning environment among minorities has been associated with a slight increase in students graduating with degrees in STEM fields over a 15-year period. However, graduation rates among White students are higher over the same period of time compared to their minority peers (Collins, 2011; Gordon, 2010; Hayden et al., 2011; Maltese & Tai, 2011; Wilson-Jones, 2011).

Need for the Study

While research has addressed some STEM issues, there remains a vacuum in the available literature for assessments on outcomes that provide clear feedback to formulate an increase in STEM learning. Specific data are needed to determine the benefits of STEM learning that will lead to improved teaching and learning efforts among all stakeholders, hence the need for this study. Providing clear outcomes that reflect instructional practices and content of the disciplines in integrative STEM will yield reliable data. This will help to advance the STEM discipline in schools and communities as they strive to effectively address the needs of all students (Hanover Research, 2011).

Studies have shown that test scores and other data outcomes are linked to operations of a program as well as the characteristics of students from different backgrounds, such as socioeconomic status, gender, and ethnicity (Boe, Henriksen, Lyons, & Schreiner, 2011; Gonzalez, 2012; Hager & Smith, 2004). Collecting and analyzing outcome-related information and comparing the findings with established STEM criteria will help to ensure that concerns regarding program implementation are addressed and improvements made to successfully develop students' engagement, capacity, and continuity in STEM fields (National Center for Literacy Education, 2012; NSF, 2010). According to the NRC (2011), there are important criteria that STEM implementations should possess in order to enhance various components of the STEM Academy (e.g., STEM blueprint, community support, quality standards-based curriculum, etc.).

The Spalding County school system in Georgia has taken on the challenge of implementing an integrative STEM Academy that will seek to capture the central tenet of the goals for U.S. STEM education, and of applying those principles and practices that have resulted in some of the nation’s highly successful K–12 STEM education schools and programs. The leadership within the Spalding School District and Griffin High School recognized the need to have effective STEM education; consequently, they are taking the initiative to use formative evaluation to ensure there will be improvements leading to the successful implementation of the Griffin High School integrative STEM Academy.

Purpose Statement

The purpose of this study was to conduct a formative program evaluation of the Spalding County–Griffin High School integrative STEM Academy. By using the discrepancy model (McKenna, 1981) approach in this formative program evaluation, the researcher identified differences between the Griffin High School STEM program and highly successful STEM programs that are meeting the U.S. STEM goals (NRC, 2011). Using the ECC trilogy as a measure, this comprehensive evaluation study not only revealed information about the value of what the program offers but also evaluated those contextual factors (i.e., gender, socioeconomic status, ethnicity/race) that will either hinder or support the degree to which an individual will commit to continue in the STEM Academy and beyond (Greene et al., 2006). For example, in an evaluation of a newly implemented integrative STEM program in one high school, researchers found that students from certain racial and ethnic groups struggled to gain success and remain in

STEM programs when compared to other groups of students (Hays, 2004). Studies have also shown that even with a state-of-the-art STEM program, if the how and why questions are not understood and if stakeholders cannot define success of STEM learning, the value of the program may not be effective (Communities Foundation of Texas, 2013; NRC, 2011; National Science Board, 2007). Moreover, studies have demonstrated that successful STEM learning is measured by three interdependent factors, one of which is engagement (Greene et al., 2006).

According to Martinez (2005), conducting program evaluation on a regular basis can greatly improve the management and effectiveness of an organization and its programs. Therefore, instead of waiting until the end of a long period to determine the success of a program, this formative evaluation study will allow for more short-term adjustments based on findings.

The purpose of this study was to conduct a formative program evaluation of the Griffin High School integrative STEM education program to identify areas that need improvement. According to Boulmetis and Dutwin (2005) and Stufflebeam (2001), program evaluations are necessary to help ensure the successful implementation of educational programs which includes the STEM initiative. Furthermore, this study will enable the Griffin High School integrative STEM program to meet established national STEM goals for the students and community.

Research Questions

The following research questions guided the study:

1. To what extent does engagement (i.e., behavioral, emotional, and cognitive) exist in the Griffin High School integrative STEM Academy for all students, including socioeconomic status, gender, and ethnicity/race?

2. To what extent does capacity (i.e., achievement) exist in the Griffin High School integrative STEM Academy for all students, including socioeconomic status, gender, and ethnicity/race?
3. To what extent does continuity (i.e., enrichment, support, access for growth and development) exist in the Griffin High School integrative STEM Academy for all students, including socioeconomic status, gender, and ethnicity/race?
4. To what extent do engagement, capacity, and continuity exist in the Griffin High School integrative STEM Academy from the teacher's perspectives?
5. To what extent does continuity exist in the Griffin High School integrative STEM Academy from the parent's perspectives?
6. To what extent does continuity exist in the Griffin High School integrative STEM Academy from the administrator's perspectives?

Conceptual Framework

This was a formative program evaluation study using the discrepancy model, and was based primarily on recent comprehensive STEM studies (Greene et al., 2006; Jolly et al., 2004; NRC, 2011). These studies that highlighted highly successful STEM schools and programs that are helping accomplish the needs of established STEM goals. There are three broad goals for the long-term implementation of STEM education in the United States. The first goal is to expand and broaden the STEM fields with students (including more women and minorities) who pursue advanced degrees. Within the STEM disciplines, Blacks, Hispanics, and low-income students are known to drop out of high-achieving STEM disciplines. The second goal is to expand and broaden the STEM-capable work force to include more women and minorities. There is evidence that the demand for a qualified STEM work force is greater than the supply of STEM applicants. Finally, the third goal is to increase STEM literacy for all students (Jolly et al., 2004).

The 21st-century work force increasingly requires more technological and scientific understanding for everyone. Therefore, even those students who will not pursue STEM-related careers will need to make technological and scientific types of decisions in their lives. The three broad goals encompass many other intermediate STEM goals that are central to the learning of STEM content and practices, developing positive STEM learning environments, and preparing students to be lifelong learners (Greene et al., 2006; Jolly et al., 2004; NRC, 2011). The goals for U.S. STEM education are central to the development of effective STEM education programs. Therefore, the established goals were central to the evaluation process and served as guidelines for the design and implementation of the Griffin High School Integrative STEM Academy.

In order to accomplish U.S. STEM goals (Greene et al., 2006; Jolly et al., 2004; NRC, 2011), this study focused its inquiry primarily on areas of concern that are necessary to develop a successful STEM education program at Griffin High School. There are a variety of conceptual connections among the STEM subjects and instructional practices to provide opportunities for making STEM learning more concrete and relevant. Developing an integrative STEM curriculum that includes scientific inquiry, engineering design, and the use of technology is vital for implementing an effective STEM program to deliver quality STEM learning. Additionally, Greene et al. (2006) contended that underrepresented and underserved minorities and women, even when they meet all requirements for STEM education and disciplines, fail to complete their learning in recognized quality STEM programs. Thus, they proposed three dimensions to help evaluate STEM educational programs: (a) knowledge, which emphasizes the four disciplines of STEM; (b) diversity, which emphasizes increasing the participation of women, ethnic and racial minorities, and those on the lower socioeconomic status ladder; and (c) pedagogy, which emphasizes effective teaching practices.

The conceptual framework represented in Figure 1 will help to provide a clearer view of the functions of Griffin High School's Integrative STEM Academy. It shows the input requirement that represent available resources as well as additional resources for the STEM program. The activities represent many of the practices that research literature indicated are effective in increasing student outcomes such as engagement (e.g., interest, motivation, attitudes, and self-efficacy), capacity (e.g., achievement and professional attainment of teachers), and continuity (e.g., community support and opportunities for students to take advance STEM courses) (Bouvier & Connors, 2011; UMass Donahue Institute, 2006). The activities are actions of all stakeholders that are geared toward providing the students as the primary stakeholders with the best possible experience in STEM disciplines, for the purpose of delivering successful outcomes.

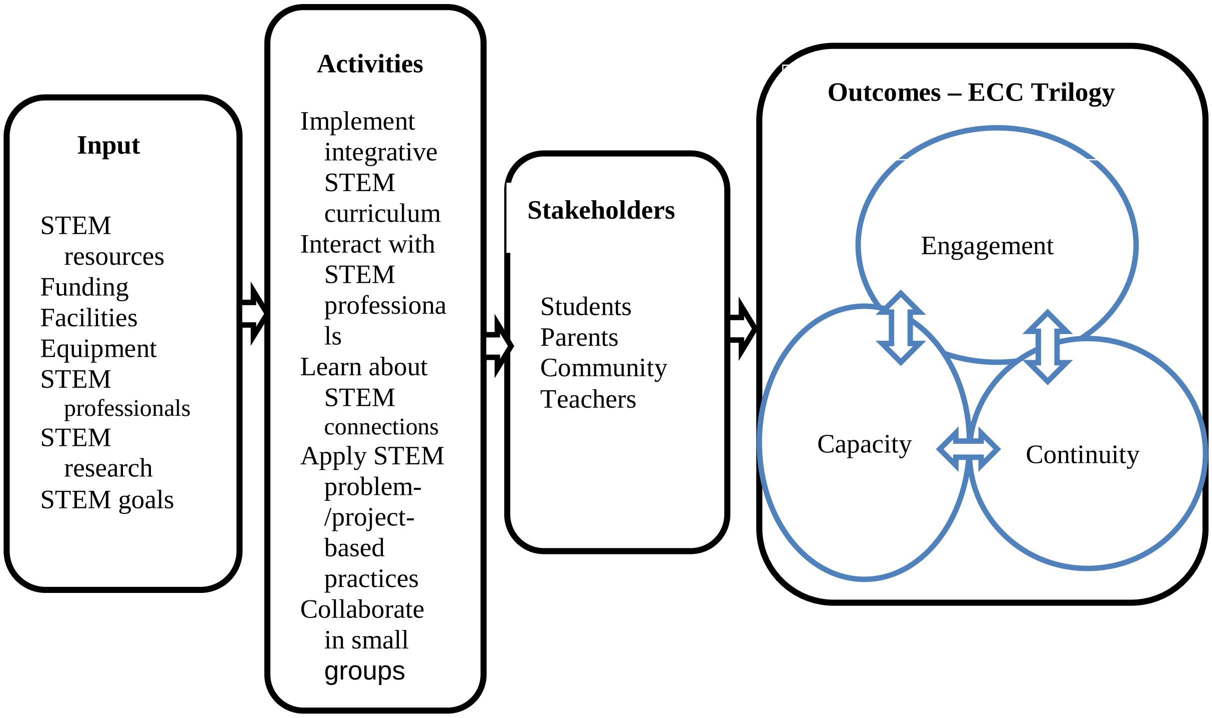

Figure 1. Conceptual framework logic model. The model shows a conceptual framework for this study that includes a combination of a logic model for the formative evaluation design and the ECC trilogy that depicts the evaluation outcome. Adapted from *Engagement, Capacity, and Continuity: A Trilogy for Student Success* (p. 3), by E. J. Jolly, P. B. Campbell, and L. Perlman, 2004, Groton, MN: Campbell-Kibler Associates. Copyright 2004 by Campbell-Kibler Associates. Adapted with permission.

The implications for successful outcomes were based on the U.S. STEM goals, which meant that the program will effectively develop positive STEM outcomes for all students, including those in minority groups and women, through the use of effective teaching practices (Board of Regents of the University of Wisconsin System, 2008; Boe et al., 2011). Implementing the program will be effective in helping Griffin High School Integrative STEM Academy to accomplish the STEM goals that will expand and broaden STEM literacy for all of its students. This will provide students of the Griffin High School Integrative STEM Academy the opportunities to complete STEM advanced degrees and will essentially be expanding the STEM work force in the local economy.

In addition, the ECC trilogy model (Jolly et al., 2004) categorizes program outcomes as engagement, capacity, and continuity and is linked to the processes and activities that will be performed within the program to accomplish the STEM goals (Greene et al., 2006; Hall, Ahn, & Greene, 2012). The ECC trilogy model (Jolly et al., 2004) was used as the framework for this research. The researcher took into account program outcomes that can be categorized into the three main components of the model (engagement, capacity, and continuity) in order to foster a clearer understanding of the functions of the integrative STEM program at Griffin High School and the improvements that will be necessary.

Engagement can be described in different ways such as by someone’s attitude, interest, or motivation. Studies (NRC, 2011; Hanover Research, 2011; & Jolly et al., 2004) suggested that students who display higher levels of engagement have less discipline problems, spend more time studying, and have better school attendance. For example, if a student receives fewer disciplines referrals, or is found to have been attending classes more frequent/ have fewer absences. Assessment of engagement can be done by opinions questionnaires. According to Lent et al. (2008) interest is the extent to which one likes, dislikes, or show indifference towards something. Therefore, engagement can be measured by how someone expressed his or her opinion towards something.

Capacity refers to the knowledge and skills gained by students. The increase of knowledge and skills are generated when students go through the activities of the STEM academy. Measures of capacity are made with the use of achievement tests that schools commonly used at the end of courses such as mathematics and science. Someone is also knowledgeable when he or she has the correct information about a subject. Therefor if the academy is implemented to provide information that students can easily process, it will be effective in helping to achieve STEM goals and increase STEM knowledge (NRC, 2011; Hanover Research, 2011; & Jolly et al., 2004).

When there is continuity students who are engaged in STEM disciplines and have a knowledge of STEM will find a much easier path to move on to the next level in the development of STEM career. By providing opportunities for students to participate in STEM-related extracurricular activities; taking advanced-level STEM courses; dual enrollment; taking the ACT/SAT; having access to professionals within a specific field; or any other opportunities, material resources, and guidance that support advancement to increasingly rigorous content in STEM disciplines (NRC, 2011; Greene et al., 2006; & Jolly et al., 2004).

According to the ECC trilogy theory, engagement, capacity, and continuity are interdependent upon each other. For example, successful outcomes of the program will only be accomplished when all three factors are met (Carnevale et al., 2011; Rockwell & Bennett, 2004). Therefore, if there is adequate engagement and capacity but little or no continuity, then the likelihood of the program accomplishing the U.S. STEM goals will be greatly impaired. If this happens to be a realistic concern for the Griffin High School Integrative STEM Academy, it will indicate that there are differences between the Griffin High School program and other programs that are meeting the STEM goals.

Significance of the Study

Griffin High School in Spalding County, Georgia, is a public school that is motivated to accomplish the goal of developing an integrative STEM program to serve the needs of its students to be competitive in the 21st century. The high school serves a diverse student population that includes a number of underrepresented and underserved student groups in STEM-related fields. Identifying the differences that may exist after comparing the findings of the study with the theoretical underpinnings may help policymakers and stakeholders to strengthen the program in an effort to meet the national STEM goals.

The researcher sought to extend existing knowledge in high school integrative STEM practice and to provide vital information to inform decision making for the growth and development of the Griffin High School Integrative STEM Academy. For high school administrators, this study may assist with the planning, design, and implementation of high school integrative STEM programs. Most importantly, the students of Griffin High School will be afforded the opportunity to acquire the scientific and technological understanding that is required in the 21st-century work force. Additionally, this study may be used as a foundation for conducting periodic evaluation studies on diverse areas of concern for continued development of effective high school integrative STEM programs.

Finally, there is the potential that the findings can be generalized to help other programs make similar improvements. High schools across the nation serve similar diverse student populations that include underrepresented and underserved student groups that may take advantage of the findings for this program to advance their STEM education programs. The need to develop effective K–12 STEM education programs is widespread, and there is increasing support from policymakers, industry, and educators in the national arena to do so.

CHAPTER 2

LITERATURE REVIEW

The acronym STEM was first used by the NSF as an educational term in the late 1990s. The NSF began to use the STEM label to help focus potential research studies; however, it is currently widely used for any event, policy, program, or practice that involves one or several of the STEM disciplines. Historically, the concept of STEM can be traced back to the period of America’s dominance as a global leader because of its technological and scientific achievement during the 20th century. A 2010 NSF report referenced a 1944 question President Franklin Delano Roosevelt asked in a letter to Vannevar Bush, the head of the U.S. Office for Scientific Research and Development at the time:

> Can an effective program be proposed for discovering and developing scientific talent in American youth so that the continuing future of scientific research in this country may be assured on a level comparable to what has been done during the war? (p. 7)

The same question is being asked today of STEM professionals all across America. In response to President Roosevelt’s question, Vannevar Bush wrote,

> The responsibility for the creation of new scientific knowledge rests on that small body of men and women who understand the fundamental laws of nature and are skilled in the techniques of scientific research. While there will always be the rare individual who will rise to the top without benefit of formal education and training, he is the exception and even he might make a more notable contribution if he had the benefit of the best education we have to offer. (NSF, 2010, p. 7)

This historical response underscores the importance of investing in STEM programs to provide quality education for students and to maintain America’s dominance. The creation of the National Aeronautics and Space Administration (NASA) in 1958 highlighted an era of America’s strong competitive spirit in science and engineering following the 1957 launch of

Russian satellite Sputnik. Former Presidents Eisenhower and Kennedy called on America to develop more talent and leaders in science, mathematics, and technology.

In his 2009 State of the Union Address, President Obama renewed the charge, noting that his administration is making the largest commitment to scientific research and innovation in American history (President's Council of Advisors on Science and Technology [President's Council], 2010). He suggested that America will not just meet but will exceed the level achieved at the height of the Space Race, through policies that invest in basic and applied research, create new incentives for private innovation, promote breakthroughs in energy and medicine, and improve education in math and science (President's Council, 2010). President Obama further pledged his commitment to provide support for American students to move from the middle to the top of the pack in science and math over the next decade so that no other nation will be able to educate more than us today or be more competitive than us tomorrow.

Goals of STEM Education

STEM education initiatives are expected to help develop interdisciplinary skills that will enable students to apply methodology and concepts from more than one academic discipline and to make connections across disciplines as necessary to find solutions to real-world problems (National Center for Literacy Education, 2012; NRC, 2011). The purposes for STEM education and the types of intellectual capital needed for the nation's growth and development are reflected in three broad goals for U.S. STEM education:

- Increase the number of students who will go on to pursue careers in STEM fields.
- Broaden the participation of women and minority groups to expand the STEM work force.

- Increase literacy in STEM disciplines for all students who may or may not pursue STEM careers (NRC, 2011).

These U.S. STEM goals are necessary for increased advanced training and careers in STEM fields, to expand the STEM-capable work force, and to increase scientific literacy among the general public—all of which are central to STEM practices and learning. These goals are central to every STEM effort in the nation to be effective (NRC, 2011).

The first goal is to expand the number of students who ultimately pursue advanced degrees and careers in STEM-related academic fields. Studies have shown there is a direct relationship between K–12 STEM education and preparing scientists and innovators to improve America's competitiveness in the global economy (Pathways to Prosperity Project, 2011). Studies have also indicated that to accomplish this goal will require more effective STEM education programs to better prepare more K–12 students to participate and remain in STEM fields (NRC, 2011). There are indications of some increase in the number of students earning STEM advanced degrees; however, shortages of STEM-capable workers to fill positions in the work force continue to exist (National Governors Association, 2011).

The second educational goal is to expand the STEM program by increasing participation of minorities and women to broaden the STEM work force. Therefore, in order to generate the best talent pool in the United States, underrepresented minority groups, such as Blacks, Hispanics, women, and low-income students, must be given a fair chance to participate and develop in STEM fields (NRC, 2011). There is no evidence to indicate there is an increase in numbers among minority groups, such as Blacks and Hispanics, involved in the STEM initiative (NRC, 2011).

According to Greene, DeStefano, Burgon, and Hall (2006), there is a powerful need to promote STEM education that includes high-quality scientific content, along with effective pedagogy that is sensitive to equity and diversity concerns. It is important to take into consideration the fact that an effective STEM program is not only defined by having quality content and appropriate teaching practices but also socially equitable in regard to access and attainment for all. For example, in Class X, a teacher might discover that a student is not showing interest in class work; the teacher would then ask appropriate questions and discover that the student does not have access to breakfast. This information might allow the school staff to make the necessary adjustment for that student to eat breakfast before class every morning. Such an adjustment in accommodating students' needs may make a significant difference in student interest and learning in school.

The third goal is to increase STEM literacy for all students. Even those students who will not pursue STEM-related careers need to understand STEM because of its global implications. We all live in a scientific and technical world in which everyone needs a certain level of related technological knowledge and skills in order to make informed decisions (National Science Board, 2007; NSF, 2010). The National Science Board (2007) contended that Americans are not being instructed to the level of competence they will need to be productive in their jobs in a global society that is technologically driven.

STEM Education in Silos

Traditionally, the four parts of STEM have been taught separately and most of the time independently from each other (M. Sanders, 2012). Science (e.g., chemistry, biology) and mathematics were viewed as the STEM norm. In practice, math and science have been emphasized more than technology and engineering in most applications of general STEM education (Brown et al., .2011). Consequently, schools remain highly departmentalized and stratified, and continue to teach subjects in isolation, with little to no attempt to draw connections among the STEM disciplines (Lantz, 2009). Teachers of science, mathematics, technology, and engineering still teach in isolated classrooms that typically do not offer much opportunity to develop real-world STEM connections and problem-solving skills. There is also a division within individual STEM disciplines. Science, for example, offers a number of instructional subject areas, such as earth science, biology, and chemistry—each of which is taught separately. Additionally, each of the STEM disciplines may include instruction in several subject areas while being taught separately (Hanover Research, 2011).

According to the Hanover Research (2011), in science, the subjects generally taught in silos include biology, marine biology, chemistry, physics, physical science, and earth science. Subjects in the technology discipline include computer, information systems, game design, software development, electrical, electronics, and mechanical technology. Subjects in the engineering discipline include chemical, civil, electrical, electronics, computer, mechanical, aerospace, and industrial engineering. Typical subjects taught in the mathematics discipline include algebra, geometry, calculus, and statistics.

Lantz (2009) noted there has been reform in the curriculum of individual STEM disciplines to reflect integration in the standards. For example, included in the mathematics curriculum are more technology-related standards. However, schools are continuing the practice of teaching individual STEM disciplines, where the instruction is heavily concentrated in a specified subject, such as mathematics, biology, or technology. According to M. Sanders (2012), the universal practice in American schools of disconnected science, mathematics, and technology education is a condition that many believe is no longer serving America well.

There are similarities as well as differences between the technology and engineering subjects of electrical, electronics, and mechanical. Engineering subjects often focus on theory and conceptual design, while technology subjects focus on practical application and implementation of engineering concepts and theory. In practice, engineering uses higher levels of mathematics and scientific knowledge and skills than does technology. For example, whether it is electrical, electronic, or mechanical engineering, multiple calculus and calculus-based theoretical science will be necessary for conceptual designs, while technology subjects are less theoretical in nature (Brown et al., 2011).

Various STEM organizations, such as the NSF and National Academies of Science, and professional societies, such as the Accreditation Board for Engineering and Technology, have acknowledged the need to increase knowledge and skills in individual STEM fields and are working to expand their policy focus beyond traditional support for basic and applied research in STEM (Carnevale, Smith, & Melton, 2011; Fairweather, 2008; National Center for Literacy Education, 2012; National Governors Association, 2007; National Science Board, 2007; NSF, 2003, 2010; U.S. Department of Education [USDE], 2011). The NSF and other similar organizations have conducted and/or sponsored several studies that have prompted the U.S. government and the nation to expand the mission of STEM learning beyond the traditional delivery systems of mathematics and science. Researchers have concluded it is necessary to develop alternative delivery methods to halt the decline in the number of students who are not showing interest in STEM fields and to increase the percentages of students' successful outcomes of STEM education when leaving school (Carnevale et al., 2011; Fairweather, 2008; National Center for Literacy Education, 2012). Creating new initiatives that will help to improve K–12 STEM education, which is of great concern for the future social and economic state of the

United States (National Governors Association, 2007; National Science Board, 2007; NSF, 2003, 2010; USDE, 2011).

According to Carnevale et al. (2011), research has shown that science, technology, engineering, and mathematics are the generators of economic power and social influence that are sustained through the capable work force it produces. Therefore, the United States needs to have a robust STEM work force to maintain its dominance and competitiveness in the global economy. This need has stirred a national debate over the effectiveness of STEM programs to quantifiably eliminate existing shortages of STEM skills in the work force (Boe et al., 2011). This comes at a time when science, technology, innovation, and related work in STEM occupations have become more integrated globally.

There are widespread concerns over a shortage of adequately prepared and interested students in STEM disciplines. Deficiency in STEM education is a threat to future economic growth, which is causing the U.S. government to invest huge financial resources to help avert a potential crisis. A 2005 report to Congress noted that among a pool of 40 industrialized countries, the United States ranked 28th in mathematics and 24th in science in an international assessment of 15-year-olds (Kuenzi, 2008). In another study, the authors reported that less than half of 12th graders met the math proficiency benchmark that indicates college readiness (Business-Higher Education Forum, 2011). The report further indicated that only 17% of 12th graders were mathematics proficient and interested in STEM careers. The report also suggested that in 2011, minority students, namely, African Americans, Hispanics, and Native Americans, were substantially underrepresented within this 17%, with less than 6% of all African American 12th graders interested in STEM careers and college ready in mathematics. Currently, the opportunities as well as the challenges for today’s work force require an interdisciplinary approach that is focused on STEM to help develop the knowledge and skills needed for career development in the 21st-century work force (Katsioloudis & Moye, 2012).

STEM Value

The value of STEM disciplines in U.S. society correlates to job creation and future economic growth (Pathways to Prosperity Project, 2011). Pathways to Prosperity Project (2011) also noted the United States will have over 1.2 million unfilled jobs in STEM by 2018. Meeting the demands of a new work force for STEM-related skills is a challenge that requires increasing attention and intervention. Jobs remain unfilled while people are in need of work. Many young adults lack the skills and work ethic needed for the many jobs that require STEM skills (Pathways to Prosperity Project, 2011).

According to the USDE (2008), there are troubling signs that the United States is now failing to meet its obligation to prepare millions of young adults. Additionally, in an era when education has never been more important to economic success, the United States is falling behind other industrialized nations in educational attainment and achievement (USDE, 2008). STEM education is important not only for the future of the society but also for individuals to have upward mobility and for families to have increased income growth and access to opportunities (Zuckerman, 2011).

Federal Actions on STEM

The STEM Education Coalition is made up of professionals, educators, scientists, engineers, and technicians in all sectors of the technological work force. Participating organizations of the Coalition are dedicated to ensuring quality STEM education at all levels from kindergarten to the university level. The STEM Education Coalition (2013) has been working to make one thing clear to the U.S. government at all levels: that improving educational achievement in STEM disciplines is about jobs and the future of America’s competitiveness in the global economy and other national priorities.

The specific goals of the STEM Education Coalition (2013) include (a) strengthening of STEM-related programs for educators and students, (b) increasing federal investments in STEM education, and (c) supporting federal investments in basic scientific research to inspire current and future generations of young people to pursue careers in STEM fields. Members of the coalition believe that America’s progress as a nation lies in improving students’ outcomes in STEM learning through the unified effort of STEM communities, including the government. Therefore, investments to maintain resources for STEM education will be provided through the nation’s budget as a means of sustaining national STEM initiatives.

Given the connection between STEM education and key national priorities, federal policymakers generally pay close attention to the U.S. STEM education system (Gonzalez, 2012). The U.S. government is engaged in a number of activities to provide support for STEM education. Approximately $25 billion was authorized to specifically target STEM education in elementary and secondary schools to prepare and inspire students to pursue STEM disciplines (President’s Council, 2010). Federal funds are available to support continued research through the NSF and other STEM-related organizations, such as the USDE and U.S. Department of Health and Human Services (USDHHS; NRC, 2011).

Additionally, funds are available to target and increase programs and resources for STEM teacher training and professional development and to increase STEM learning for all students (Feller, 2011). Despite past efforts by federal and state governments in support of innovation and competitiveness to increase the STEM work force, there is growing frustration over a lingering shortage of adequately prepared and interested students who take part in STEM-related instructional programs (Gall, Gall, & Borg, 2003). Several studies, including a report to the president, have depicted a far-lower-than-average progress of students' success in STEM disciplines (President's Council, 2010). However, the U.S. government is motivated to invest funds to ensure that effective programs and resources are available to effectively expand and broaden STEM learning.

Postsecondary Institutions' Integrative STEM Education Programs

In 2005, the education department at Virginia Polytechnic Institute and State University introduced an integrative STEM education program that was based on principles for the teaching and learning of science and mathematics concepts and practices through technological/engineering design-based instructional activities (M. Sanders, 2012). According to M. Sanders (2012), the integrative STEM educational approach adopted by the school intentionally integrated concepts and practices of STEM disciplines as an inclusion of all disciplines in its teacher education preparation program.

The university eliminated the separate departments of mathematics education, science education, and technology education to create the new integrative STEM education graduate program for all disciplines in the STEM education fields. This approach is expected to impact the learning environment for professionals in the institution who are trained together and are challenged to be agents of change from the era of teaching in isolation to a practice of integration (Wells, 2013).

Clemson University also has a new STEM institute designed to train the next generation of teachers in integrative STEM learning (College of Health, Education, and Human Development, 2013). Training teachers to integrate STEM will help to expand their capabilities to inspire students who need to be prepared for the STEM-based knowledge and skills that are needed in the 21st-century work force (College of Health, Education, and Human Development, 2013). Clemson University's STEM institute is one of the forerunners equipping teachers for integrative STEM education programs that are increasingly being implemented nationwide due to the investments in STEM initiatives by the U.S. government (President's Council, 2010).

According to M. Sanders (2012), successful STEM learning outcomes of students are reflected in their ability to demonstrate integrative STEM knowledge and skills; to effectively use grade-appropriate STEM concepts and practices in designing, making, and evaluating solutions to authentic problems; and to demonstrate STEM-related attitudes and dispositions. When teachers expose students early to opportunities to learn mathematics and science in interactive environments that develop communication and collaboration skills, students are more confident and competent in solving problems (Laboy-Rush, 2012).

Integrative STEM Education K–12 Programs

Vannevar Bush's response to President Roosevelt's question in 1944 may suggest that STEM education topics have long been in existence. According to the NRC (2011), many people tend to think about effective STEM schools in terms of different school types or programs that focus on STEM, such as magnet schools and career academies. Researchers have asked if it is possible to have a truly integrative STEM education program (NRC, 2011).

A Hanover Research (2011) study suggested that STEM-focused schools find innovative methods for structuring the curriculum, developing new instructional techniques, recruiting highly qualified teachers, providing opportunities for extracurricular activities, and fostering connections with the professional STEM community. According to the NRC (2011), STEM-focused schools and programs provide more opportunities for integrative STEM education curriculum to be implemented than traditional school systems. In addition, the study suggested it is conceivable that a specific school type or program, on average, produces stronger student outcomes than do traditional schools. These outcomes provide greater significance for stakeholders to support the efforts to implement integrative STEM programs and schools. Such schools and programs are important because they can serve as exemplars for districts across the nation, which as a whole is attempting to elevate the quality of STEM learning.

Integrative STEM education is a relatively new phenomenon within the K–12 environment that is easy to be conceptualized but rather difficult to be implemented. This is primarily due to challenges such as the need for additional preparation time for teachers, materials and resources, inventory storage, and supportive administration and collaborative team approaches (Laboy-Rush, 2012). On the other hand, Laboy-Rush (2012) cited a variety of ways in which integrative STEM education already exists through project-based learning. For example, there are robotics, EBD, and PLTW activities designed with project- and inquiry-based methods for integrative STEM education programs. While it is apparent that integrative education is possible, systematically there are challenges in the K–12 education system related to the integration of STEM program implementation. As Laboy-Rush noted, overcoming challenges toward integration will require administrative support and teacher creativity to create a clear vision for integrating STEM learning and to manage preparation time and school resources. Knowing what it is that has to be achieved is important in choosing the right approach for the implementation of an integrative STEM education program.

Integrative STEM Blueprint

Integrative STEM blueprints have been credited for successes cited in some of the United States' most successful STEM schools and programs (NRC, 2011). Primarily, the state of Texas has developed and followed a comprehensive blueprint for its High School Project STEM initiatives. It is believed that the T-STEM academies' design blueprint is a platform that may help students not only in the state of Texas but also nationally to thrive in the 21st-century economy by studying and entering into STEM fields (Communities Foundation of Texas, 2013). This blueprint has been credited for successful outcomes that reflected increases in mathematics and science test scores in T-STEM schools. The T-STEM initiative document description of the blueprint is as follows:

> The T-STEM initiative aims to closely align high school curriculum with admission requirements of competitive colleges and the STEM qualifications for 21st century jobs. The Academies use the T-STEM Design Blueprint, Rubric, and Glossary as a guidepost to build and sustain STEM schools that address the seven benchmarks: [a] mission driven leadership; [b] school culture and design; [c] student outreach, recruitment, and retention; [d] teacher selection, development and retention; [e] curriculum, instruction, and assessment; [f] strategic alliances; and [g] academy advancement and sustainability. (Communities Foundation of Texas, 2013, p. 2)

Each benchmark provides a formative and comprehensive evaluation instrument for a 5-year period that will monitor the STEM program on a path to improvement beginning with the developmental stage and moving to its full maturity. The T-STEM Academy blueprint initiative is fully funded through public and private funds and may serve as a model for STEM initiatives for other states or any local school system (Communities Foundation of Texas, 2013).

Successful STEM Education

The NRC created a committee of experts in October 2010 to identify highly successful schools or programs for K–12 STEM education. A report was generated that described types of STEM-focused programs (primarily high schools) from across the country that fit the profile based on the criteria that were established by the NSF committee (NRC, 2011). Although integrating STEM subjects was not the focus of the study, the variety of conceptual connections among STEM subjects and the fact that science inquiry and engineering design provide opportunities for making STEM learning more concrete and relevant were recognized.

Integrative STEM, however, is the focus of studies being conducted by the NRC (2011). The NRC report highlighted successes in three categories of schools that were studied: “selective STEM schools, inclusive STEM schools, and schools with STEM-focused career and technical education” (p. 7).

Selective STEM Schools

Selective STEM schools are established with selective admissions criteria and are organized around one or more STEM disciplines. Usually highly talented and motivated students with a demonstrated interest in and aptitude (engagement) for STEM are enrolled in these schools in small numbers (NRC, 2011). Additionally, the NRC (2011) identified four types of selective STEM schools: (a) state residential schools, (b) standalone schools, (c) schools-within-schools, and (d) regional centers with half-day courses. All of the selective STEM school types seek to provide high-quality education that prepares students to earn STEM degrees and succeed in professional STEM careers. They support student learning with expert teachers, advanced curricula, sophisticated laboratory equipment, and apprenticeships with scientists (continuity). These schools often provide professional development (capacity) and supplementary programs to teachers and students from public schools in their regions (NRC, 2011).

An example of a selective school is the North Carolina School of Science and Mathematics (NCSSM). The NCSSM is a state residential school established in 1978, and in 2010–2011 had an enrollment of about 680 residential students with demographics of 61% White, 15% Black, 1% Hispanic, 22% Asian/Pacific Islander, and less than 1% Native American (NRC, 2011). The NRC suggested the NCSSM met all criteria as the available data indicated that students such as these are more likely to complete STEM majors than their peers who do not have the following: (a) research experiences in high school, (b) the provision of apprenticed mentorships or internships, and (c) teachers who have the capability to offer integrative STEM content. Students who had the aforementioned criteria also reported higher test scores than their peers (NRC, 2011).

Inclusive STEM Schools

Inclusive STEM schools are focused on STEM disciplines but have no admissions criteria. These schools are designed to serve the broader population, including students from traditionally underrepresented minority groups who need access to opportunities to develop STEM competencies. An example of an inclusive STEM program is at the Manor New Technology High School, a standalone school that was established in 2007 as a T-STEM academy. It is located in Austin as part of the Texas High School Project. The student population in 2009–2010 was approximately 315 students, 32% of whom were White, 22% Black, 44% Hispanic, and 2% Asian/Pacific Islander. A project-based pedagogical approach is applied to offer engaging and collaborative opportunities for learning. The use of technology is integrated across the curriculum. The school climate is based on trust, respect, and responsibility, with high expectations for all students to take high-level mathematics and science courses (NRC, 2011).

In Texas, the results from studies have shown that students from the state’s 51 inclusive STEM schools have higher mathematics and science achievement test scores when compared to their peers in other schools. The schools have also reported better attendance records and that the students are more likely to take advanced-level courses (NRC, 2011). The NRC (2011) credited the following for these results:

> A STEM school blueprint that helps to guide school planning and implementation, a college preparatory curriculum and explicit focus on college readiness for all students, strong academic supports, small school size, and strong support from their district or charter management organization. (p. 11)

This statement again highlights the importance of administrative support for flexibility within the school systems to implement STEM programs.

Schools and Programs With STEM-Focused Career and Technical Education

STEM-focused career and technical education (CTE) schools and programs are commonly housed in CTE-focused high schools that offer programs in comprehensive high schools and career academies. The goals of STEM-focused CTE include preparing students for STEM-related careers and increasing students' engagement through practical applications of STEM subjects and various CTE delivery systems (National Science Board, 2007). It is widely accepted that CTE programs provide motivation through real-life learning applications and support academic achievement (Becker & Park, 2011; Boe et al., 2011; Hyslop, 2010; Nugent, Barker, Grandgenett, & Adamchuk, 2010; M. Sanders, 2009**)**. However, their true value is undetermined because of limited research. The NRC (2011) suggested there are potentially promising findings from the studies that have been done.

A very limited number of studies have been conducted to conclusively indicate that specialty STEM schools do better than regular schools in educating students to connect with and employ STEM learning goals (Hanover Research, 2011). The students in selective high schools are usually selected with greater interest and/or aptitude in STEM subjects, which may help to explain why there is some indication that graduates from STEM schools tend to pursue and complete STEM major degrees. The NRC (2011) further emphasized that

> In particular, students who had research experiences in high school, who undertook an apprenticed mentorship or internship, and whose teachers connected the content across different STEM courses were more likely to complete a STEM major than their peers who did not report these experiences. (p. 9)

Since the 1990s, STEM education has been evolving, where individual disciplines once were only practiced in isolation. Today, the practice of STEM education has been expanded to a new paradigm called *integrative STEM education*. This term, too, can be just as confusing as the original *STEM education*. Guided by research, experts have been able to define *integrative STEM education* (M. Sanders, 2012; Wells, 2013); however, it is not yet clear if this definition will be acceptable to everyone. For example, how many more institutions will condense their individual teacher training departments for science, math, and technology into an integrative STEM program? How are K–12 schools prepared to transition from teaching STEM disciplines in isolation to a practice of integration? Thus, all aspects of integrative STEM programs, from the design stage to the resulting outcomes and impacts, must be carefully evaluated and researched to ensure the effectiveness and success of newly implemented programs. Government policies and investment efforts must also give school leaders the flexibility to be transformational in making the necessary changes for the implementation of integrative STEM education (M. Sanders, 2012; Wells, 2013).

Georgia STEM Education Initiatives

Different STEM efforts are being made throughout the state of Georgia at different levels to increase STEM learning. The NRC (2011) and Hanover Research (2011) identified the nationally recognized Oakcliff Elementary School in Georgia as an example of a successful inclusive STEM school. The Georgia STEM initiatives are being channeled through STEM Georgia, a department within the GADOE (2011). STEM Georgia (2013) has also established the criteria for determining successful STEM schools and programs. STEM Georgia uses rubrics to evaluate schools and programs that determine whether schools and programs have met the Georgia STEM goals. Such schools and programs would then be labeled as STEM schools or programs once they meet these criteria. According to STEM Georgia, the STEM schools in Georgia include Wheeler High School; Gwinnett School of Mathematics, Science, and

Technology; Rockdale Magnet School for Science and Technology; Kennesaw Mountain High School of Academy of Mathematics, Science and Technology; Henderson Mill Elementary School; and Carrollton Elementary School.

Georgia STEM Goals

STEM Georgia (2013) has established STEM goals for school districts and schools in the state of Georgia:

1. Empower students to become innovators and technologically proficient problem solvers.
2. Ensure that all students have access to the appropriate technology conducive to enhancing their learning experiences both in and outside the traditional classroom.
3. Increase students’ 21st-century skills and technological literacy by providing students with opportunities to use the technical tools of the STEM industry.
4. Guide community understanding of the importance of STEM education and build capacity to sustain a viable STEM educational program to prepare students for work and life in the 21st century.
5. Increase Georgia’s capacity to provide high-quality K–12 STEM professional learning opportunities.
6. Nurture partnerships that allow schools and the business sector to join efforts to improve students’ STEM-career opportunities.
7. Increase the number of students pursuing careers in STEM-related fields and/or postsecondary STEM-related education/training.

The Georgia STEM goals are relative, similar to the U.S. STEM goals, with some overlapping ideas. The U.S. STEM goals are as follows:

1. Expand the number of students who ultimately pursue advanced degrees and careers in STEM fields and broaden the participation of women and minorities in those fields.
2. Expand the STEM-capable workforce and broaden the participation of women and minorities in that workforce.
3. Increase STEM literacy for all students, including those who do not pursue STEM-related careers or additional study in the STEM disciplines. (NRC, 2011, p. 5)

The assumption is that these two sets of STEM goals will lead to positive STEM learning outcomes in the state of Georgia and nationwide (GADOE, 2011). For example, Georgia STEM Goals 2 and 7 together are similar to U.S. STEM Goal 1. Similarly, Georgia STEM Goals 1, 3, and 6 are related to U.S. STEM Goal 2, and Georgia STEM Goals 4 and 5 are related to U.S. STEM Goal 3. One might also consider the relationship between the Georgia and U.S. STEM goals to be overlapping, where a Georgia STEM goal is similar to two different U.S. STEM goals. For example, Georgia STEM Goal 7 is to increase the number of students pursuing careers in STEM-related fields and/or postsecondary STEM-related education/training (similar to U.S. STEM Goal 2 of expanding a STEM-capable work force) and to expand the number of students who ultimately pursue advanced degrees and careers in STEM fields (U.S. STEM Goal 1). Other overlapping relationships may be found in other goals that are supported by the NRC (2011), which noted that the three broad U.S. STEM goals represent many STEM goals being used across the United States. Therefore, as a test of whether a program implementation will effectively support STEM education, the goals of such a program must reflect similar characteristics as those reflected in the three U.S. STEM goals (GADOE, 2011).

Griffin-Spalding County STEM Blueprint

The suggested STEM goals of the integrative STEM Academy of Griffin High School were discussed with the principal and core staff members of the Academy. The suggested goals of the integrative STEM Academy are as follows:

7. Allow students to make connections among STEM disciplines and careers.
8. Increase students' engagement and capacity and improve continuity in STEM disciplines and related careers.
9. Provide students with alternative STEM learning opportunities and enrichment.
10. Provide a welcoming STEM learning environment to increase participation of all students, including minorities and women.

Also important is that the goals of the Griffin High School integrative STEM Academy bear similarities to the U.S. and Georgia STEM goals in order to develop successful STEM education programs (NRC, 2011). These goals will be revised for improvement regarding any discrepancies between the STEM goals of Griffin High School integrative Academy and the U.S. STEM goals.

Strengthening STEM education has become the priority of the Griffin-Spalding County Schools in Georgia. Under the leadership of the superintendent and deputy superintendent, the Griffin-Spalding County School system is in partnership with Griffin-area businesses and industries, colleges and universities, as well as national and state-level corporate and educational partners to promote workforce development and to identify and cultivate the next generation of creative STEM innovators.

As a partnership, the Center for Education Integrating Science, Mathematics, and Computing (CEISMC, 2012) has been connecting the Georgia Institute of Technology with educational groups, schools, corporations, and opinion leaders throughout the state of Georgia to develop a STEM blueprint for the Griffin-Spalding County School System. This county-wide STEM blueprint focuses on the development of STEM education programs and activities at the elementary, middle, and up to the ninth-grade high school levels (CEISMC, 2012).

In keeping with the goals of STEM and the Griffin-Spalding County partnership for STEM education, Griffin High School developed a curriculum alignment of STEM disciplines for an integrative STEM Academy in the 2012–2013 school year for Grades 10–12. With support from the Griffin-Spalding STEM blueprint, STEM staff members in individual STEM disciplines came together to develop the Griffin High School STEM curriculum. Teachers in the engineering and technology, mathematics, and science disciplines met for three days in the summer of 2012 to develop an integrated STEM curriculum outline which was used in the implementation of the integrative STEM academy to meet the STEM goals at Griffin High School.

The formative evaluation process is employed to monitor the implementation process in order to achieve a highly successful STEM Academy that promotes STEM learning. According to experts (Boulmetis & Dutwin, 2005; Bybee, 2010; Greene et al., 2006; Stetler et al., 2006; Stufflebeam, 2001; Trochim, 2009; U.S. Government Accountability Office, 2012), formative evaluation is necessary for successful program implementation in identifying areas that need improvement. The Griffin High School integrative STEM Academy chose the formative evaluation process to ensure that a successful integrative STEM education program would be developed with the help of this study.

Program Evaluation Theories and Approaches

One of the challenges for a researcher is to be able to be definitive about the conclusions that are drawn from the data collected (Trochim, 1982, 2006). In this study, for example, if the conclusions must be relevant to the Griffin High School integrative STEM program in order to develop a successful STEM program, there must be proven accountability. Stakeholders must be made aware that the data collected about the program outcomes are clearly linked to activities and processes that are exerting influence on the outcomes (Boulmetis & Dutwin, 2005).

According to Lewis (2001), the construct of the study should be operationalized, which means the construct must be clearly defined so it can be clearly measured. In this study, the constructs of engagement, capacity, and continuity were defined by theory, which gives a clear understanding of what was measured for program outcomes. Both theory and practice were necessary to show that the collected data of the construct variables are results of the program activities and processes with proven validity and reliability.

According to Allen and Yen (2002), the definition of the construct enhances the validity and reliability of the research process. The terms *validity* and *reliability* are widely used in the field of research in association with the collection of data (Gloeckner, Gilner, Tochterman, & Morgan, 2001). To determine validity, the researcher asks, “Are you really measuring what you think you are measuring?” while to determine reliability, the researcher asks, “How consistent is that measurement?” This means an instrument may not be valid because it does not fulfill the purpose for which it was selected and the data will not be in sync with the constructs. On the other hand, the instrument would be reliable because it generates data whenever it is in use (Messick, 1995; Moss, 1998; Reckase, 1998). The collection of usable data that have both validity and reliability will be achieved if a clear and systematic understanding of the constructs of the study are supported by the theory presented (Gloeckner et al., 2001).

A theory is a concept that is used to guide the practice of evaluation and to show the direct link of the influence of certain factors on program outcomes (Trochim, 2009). Theory provides a systematic way to improve and account for actions by involving procedures that are useful, feasible, ethical, and accurate for program evaluation to be effective. The theoretical framework guides the practices that are used for program evaluations (Stufflebeam, 2001; Tang, 2012; Trochim, 2009; USDHHS, 1999). Which theory best supports the evaluation study of the integrative STEM program at Griffin High School? Formative evaluation theories that include the background information, guiding principles, and implications for human resources were reviewed to support its application for this study. Also, in order to explain the main constructs for a clearer understanding of program activities and what improvements will be necessary, the ECC trilogy theory was utilized.

The evaluation theories and approaches were chosen to determine how best to carry out the evaluation with a focus on assessing the extent to which the STEM program at Griffin High School will successfully advance the goals of U.S. STEM education. A theory is a concept or abstract principle that serves as a frame of reference for the program evaluation functions; similarly, an approach is the perspective toward how the program evaluation must function (Duarte-Laudon & Gilbert, 2010; Stufflebeam, 2001; Trochim, 2009; USDHHS, 1999). Many experts have used the terms *theory* and *approach* interchangeably as guidelines needed for program evaluation (Boulmetis & Dutwin, 2005; Stufflebeam, 2001; Trochim, 1982). The professional literature related to program evaluation makes mention of various types of evaluation approaches ranging from process and outcome evaluations to meta-evaluation and several other evaluation-related concepts (e.g., baseline, stakeholder, qualitative, quantitative). However, no one approach is more highly rated than the others for all evaluation purposes. Strengths and weaknesses are associated with each approach or theory. Sometimes two or more approaches are combined when conducting an evaluation. Each approach has an associated set of steps designed to guide evaluation processes and activities. Different approaches provide flexibility and choices for conducting program evaluation (Boulmetis & Dutwin, 2005). For example, there are approaches that may allow the evaluator to work either independently or jointly with stakeholders throughout the evaluation process.

Program evaluation is a concept and process that began taking root in the 1960s. Since then, there has been wide use of program evaluation practices for varied purposes. In order for evaluation practices to be implemented constructively and with integrity, guiding theories have been developed by evaluators based on beliefs and assumptions of how programs function.

Formative Evaluations

Formative evaluations are traditionally aimed at identifying ways to improve a given program. This type of evaluation focuses on programs in the developmental phase, and is used in the planning stages of a program to ensure the program is developed to meet the needs of its stakeholders. Additionally, formative evaluation is used as a guide for programs to utilize materials and procedures appropriately and effectively (Boulmetis & Dutwin, 2005; Preskill & Russ-Eft, 2005; Stetler et al., 2006; Stufflebeam, 2001; Tang, 2012; Trochim, 2009; Worthen, Sanders, & Fitzpatrick, 1997). Formative evaluation also emphasizes the roles of stakeholders in the evaluation process through different evaluation approaches. Three approaches that are commonly recommended when performing formative evaluations are the participatory intervention model, the discrepancy model, and the goal-based model.

Formative evaluation examines the procedures and tasks within a given program and seeks to clarify the services being delivered as well as the recipient of those services. It examines various short-term outcomes of the STEM program being implemented to facilitate improvements that need to be maintained throughout the progression of the program. The collected data are then analyzed to ensure the implementation of the program is achieved (Worthen et al., 1997). For example, if the integrative STEM program is to be a success at Griffin High School, it is important to know to what extent the program will actually be implemented based on the design of the program. Figure 2 depicts the sequence of how tasks are usually conducted. As shown in the figure, the tasks involved in a formative evaluation study typically are (a) identification of evaluation goals, (b) needs assessment, (c) planning of data collection (i.e., contributing to methodological choices and making value judgments), and (d) using the findings of the formative evaluation to make improvements.

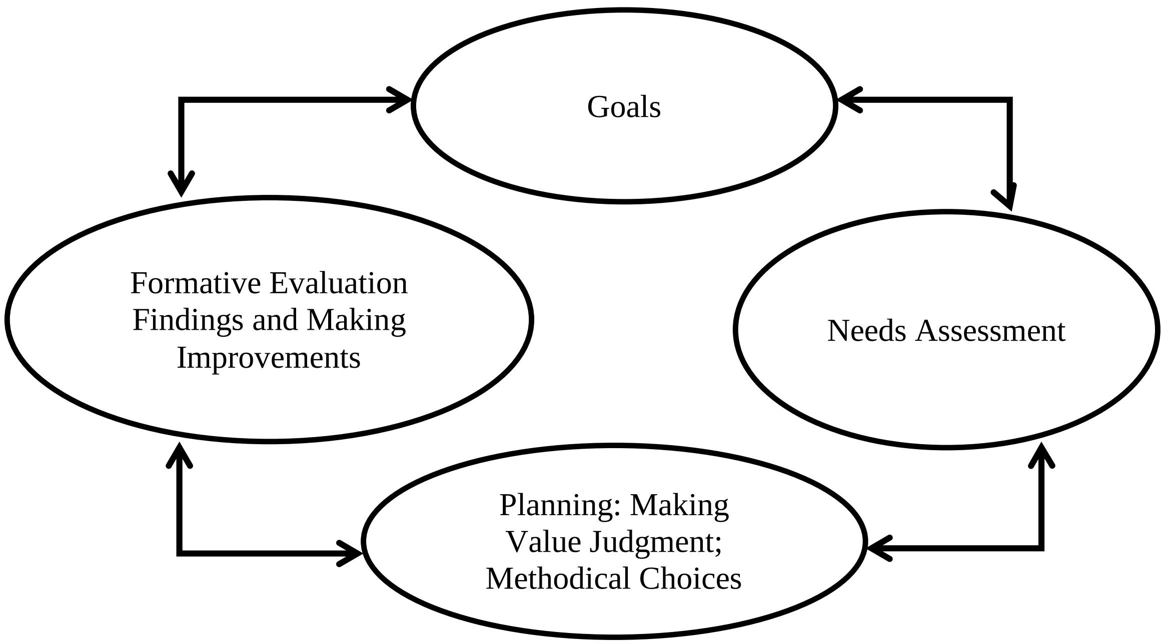

Figure 2. Program cycle for conducting formative evaluation. Adapted from *The ABCs of Evaluation: Timeless Techniques for Program and Project Managers* (p. 40), by J. Boulmetis and P. Dutwin, 2005, San Francisco, CA: Wiley. Copyright 2005 by Wiley. Adapted with permission.

In the first phase of the formative program evaluation cycle, the evaluator will determine what the mission and goals of the organization are in order to decide which activities and processes are necessary to be incorporated into the program being implemented. For example, the decision might be made to eliminate all activities that cost over 10% of the organization's budget.

Next, a needs assessment is conducted to determine what activities should be carried out in order to effect the most meaningful improvements. The results from the needs analysis will provide the basis upon which an evaluator can make valuable informed decisions and methodological choices that involve clarifying the program goals, which will be helpful in identifying the possible nature of needs that may exist. The needs assessment will also focus on any previous activities or parts of the program cycle that have been completed (Boulmetis & Dutwin, 2005; Worthen et al., 1997). Moreover, the results of the needs analysis will be used to identify resources and formulate the program planning necessary to move the program forward in a more effective manner.

The planning phase is third in the life cycle of a program evaluation. Goals or objectives that are of high priority must be identified and aligned with appropriate methods for achieving the intended outcomes that are selected during this cycle. The program planner will decide on the activities included in the program that are necessary to produce effective changes. Whether it is necessary to get rid of old activities, modify old activities, or initiate new activities are questions the evaluator must answer during this phase. The planning phase is culminated with a compilation of evaluation questions in the program plans that are submitted to the sponsors and stakeholders of the program (Boulmetis & Dutwin, 2005).

The evaluation design is a guide for the successful implementation of a program and provides an opportunity to discuss questions and methodological approaches that are appropriate. A well-designed evaluation that carefully lays out the methodological strategy, planning the data collection methods, and data analysis will be a powerful aid in implementing the program (Boulmetis & Dutwin, 2005). Questions are constructed so that the issues and concerns expressed by stakeholders about the program can be communicated. The questions should direct the program evaluation implementation to help ensure the findings will be relevant to the issues and concerns. A strong foundation in program evaluation provides more convincing conclusions and recommendations. Additionally, if the design has been previously established, the program implementation will be strengthened and less time will be lost in trying to make unplanned decisions about what to do next. Taking time for preplanning can reduce the many uncertainties of an evaluation and provide a clear sense of direction and purpose (Boulmetis & Dutwin, 2005; Worthen et al., 1997).

The Engagement, Capacity, and Continuity Trilogy

The ECC trilogy (see Figure 3) is a theory that seeks to explain factors that play an interdependent role in analyzing outcomes in STEM disciplines. The underlying assumption of the ECC trilogy is that the three factors must be present for student success to be achieved. The ECC trilogy theory consists of three components: (a) engagement, which emphasizes the possession of qualities such as awareness, interest, and motivation through an orientation to the STEM disciplines; (b) capacity, which deals with the acquired knowledge and skills needed to advance to increasingly rigorous content in the STEM disciplines; and (c) continuity, which deals with having access to institutional and programmatic opportunities, material resources, and guidance that support advancement to increasingly rigorous content in STEM disciplines (Jolly et al., 2004).

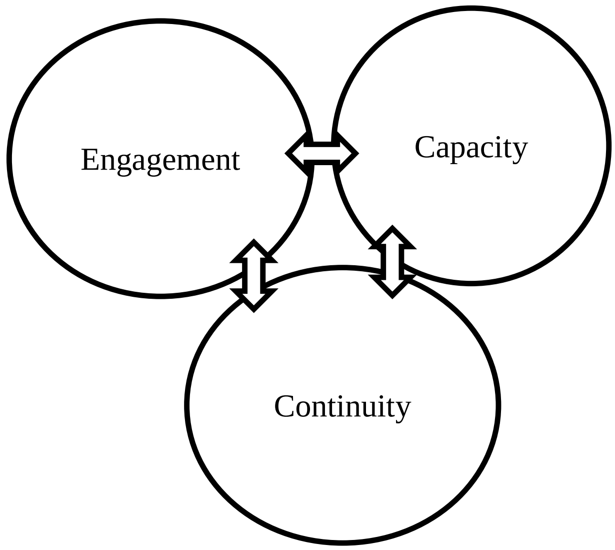

Figure 3. ECC trilogy. Adapted from *Engagement, Capacity, and Continuity: A Trilogy for Student Success* (p. 3), by E. J. Jolly, P. B. Campbell, and L. Perlman, 2004, Groton, MN: Campbell-Kibler Associates. Copyright 2004 by Campbell-Kibler Associates. Adapted with permission.

The ECC model needs all three components (engagement, capacity, and continuity) to be accounted for in the development of STEM programs to ensure successful student STEM learning outcomes in STEM disciplines and careers (Felix et al., 2010; Feller, 2011; Jolly et al., 2004; Verma et al., 2011). The absence of the engagement factor can have an impact on the degree to which there will be capacity or continuity. For example, without knowledge and skills (i.e., tests scores that are acceptable for admission into college), many individuals will not be able to take advantage of available opportunities and resources in higher education to earn STEM-related degrees. It is imperative to ensure that the design and implementation of a STEM academy take into consideration criteria for increasing engagement, building capacity, and providing support for continuity, which are essential for students to advance in the STEM disciplines (Jolly et al., 2004), which may lead to the completion of advanced STEM degrees and the skills that are necessary to meet the demands of the 21st-century STEM work force.

The ECC trilogy can help to frame evaluation designs and contribute to the understanding of improvements that are necessary for a successful integrative STEM program. Having ECC indicators at the individual student level can help explain the need for broad actions that will positively affect STEM learning for students. For example, if after certain actions, such as the implementation of new teaching strategies, are applied in a STEM program to build capacity, and the outcome of the program shows decreasing test scores instead of an increase, would it mean the teaching strategies are ineffective? Or could there be factors affecting the test scores other than the teaching strategies? Could it be the wrong students were targeted, such as students who lack interest and motivation (engagement), or students who lack access to opportunities such as adequate preparatory STEM courses and money to pay for an extracurricular STEM activity (continuity) as well as the skills to persist? It is important to focus the evaluation on outcome measures and data sources of all three factors of the ECC trilogy and to periodically reassess the program and participants to look for areas in need of improvement as well as to determine if the needs have changed (Greene et al., 2006; Jolly et al., 2004).

As a result, the three broad interdependent factors—engagement, capacity, and continuity—that are necessary for student success in a STEM program (Jolly et al., 2004) were the central concept in this study. If a program is successful, the outcomes of the program design will reflect a clear pathway for significant increases in STEM knowledge (capacity); will provide clear indicators for advancement in STEM disciplines and in the STEM-related work force (continuity); and will increase the motivation, interest, or self-efficacy (engagement) of students and staff involved in STEM practice.

The ECC trilogy model was a suitable framework for this study. The model emphasizes the need to address issues of underrepresentation of minority students in STEM fields. For example, the model can help to provide data to ascertain why the program is not supportive enough of women with engagement and capacity to continue in STEM fields. Additionally, the framework is suitable for assessing the degree to which individuals possess the factors of engagement, capacity, and continuity that are needed for successful STEM learning. Moreover, ECC trilogy-related data have the potential to describe student success that is linked to the program's growth and development (Jolly et al., 2004).

Common Approaches to Formative Evaluation

Three of the popular current approaches used in conducting formative program evaluations are the participatory intervention, discrepancy intervention, and goal-based models. However, several authors have described the uses of many approaches to program evaluation that are available in the literature (Boulmetis & Dutwin, 2005; Worthen et al., 1997). These approaches are discussed briefly in this section.

Discrepancy Evaluation Model

The discrepancy evaluation model (DEM) was first developed by Boulmetis and Dutwin (2005) for the purpose of providing information that will aid program assessment and program improvement. DEM evaluation compares an actual performance to a desired standard. There are five stages of evaluation based on a program's natural development: program design, installation, process, product, and cost–benefit analysis. This evaluation provides information to facilitate rational decision making in relation to program design or analysis, decisions concerning the achievement of both intermediate and final goals, and decisions about the program in operation (Boulmetis & Dutwin, 2005; Stufflebeam, 2001).

In the DEM, areas of concerns are identified by comparing program performance (i.e., outcomes such as achievement) in STEM disciplines with established criteria that are based on standards. Discrepancies can occur after initial program implementations are identified when comparisons are made. *Program performance* is defined as the program implementation, results, and/or outcomes. The program design standards and/or criteria are the objectives or goals (McKenna, 1981). The DEM is suitable for evaluating a STEM program because it is part of a broader national organizational structure in which there are standards that can be compared to help determine how well the program is performing. The model does not necessarily prove causes and effects but rather performs an examination about the causes and effects to enable reasonable assumptions to be made. The DEM is more concerned about why students may have improved their performance rather than what their actual performance is. The DEM can be used to evaluate a program throughout the full cycle, which includes various stages of design, installation, process, product, and cost–benefit analysis. Each stage must be provided with its own set of standards (Boulmetis & Dutwin, 2005). With this model, decisions can be made about the differences between the STEM national goals and what actually exists within a specific program, such as the integrative STEM program at Griffin High School.

Participatory Intervention Model

In the participatory intervention model, all major stakeholder groups are allowed active inclusion at every step of the research process. This model lays the foundation for context-specific interventions based on theory and research in the development of what is necessary to promote desired outcomes (Duarte-Laudon & Gilbert, 2010). In order to utilize the participatory intervention model, evaluators must devote time and energy to the development of partnerships, engage in formative research, and conduct a comprehensive evaluation of the program (Nastasi et al., 2000).

Participation in the evaluation engages stakeholders in a process of discovery and analysis and can bring into focus stakeholder ownership and increases the chances that findings are more likely to be acted upon. The participatory intervention model provides learning opportunities for stakeholders that can have positive effects on the program over the long term. However, there can be also negative consequences due to stakeholder bias. For example, stakeholders may overlook certain weaknesses and overemphasize the strengths for their own purposes that are not aligned within the scope of evaluation goals.

Goal-Based Model

The goal-based model is also known as the objective attainment model. This model is thought to be the easiest to use and is most frequently used by evaluators and researchers. The principle of this evaluation is based on stated objectives and program goals found in the description of the program. It is used in either quantitative or qualitative models to measure specified outcomes that are not concerned with auxiliary items, variables, or occurrences that might result from the program activities (Stufflebeam, 2001).

The goal-based model is an approach that was under consideration to evaluate the Griffin High School integrative STEM program. It is relatively simple, widely used, and designed to look for improvement in a program, which was clearly the purpose of this study. The evaluation was based on objectives and goals found within the description of the program. Therefore, the Griffin High School STEM program staff need to first adopt its goals from the broadly stated national STEM goals in relation to its local context. By so doing, the focus will be strictly on the objectives, which will usually determine what tests or standards must be applied so that a measure (i.e., qualitative or quantitative) can be accomplished (Boulmetis & Dutwin, 2005). This evaluation will allow the staff to develop clearly stated goals that are realistic and can be used to help improve the STEM Academy at Griffin High School. This evaluation process will involve the collection of data to provide feedback to the stakeholders—in this case, the teachers—so that improvements can be made. The goal-based model approach can be used to manipulate the variables and treatment to determine cause and effect of outcomes, thus providing information that will effect more exact changes (Cheng, Sawyer, Bencomo, & Whittle, 2009).

According to Cheng et al. (2009), the goal-based model offers the advantage of identifying and visualizing the different alternatives for satisfying the overall objectives of program evaluation. Although the real need in this study was to increase STEM learning, the reality from reviewing the STEM literature is that contextual factors, such as gender and ethnic/racial diversity, cannot be ignored. The focus of several national STEM organizations, such as the NSF, National Academies of Science, and professional societies, such as the Accreditation Board for Engineering and Technology, has been used to bring awareness of STEM knowledge and skills and to expand policies that provide the necessary support that will strengthen STEM educational initiatives for all Americans (NSF, 2010). Inherently, there is a call for increased funding and equity that will foster better diversity and creativity in the work force (Carnevale et al., 2011; Fairweather, 2008; National Center for Literacy Education, 2012; National Governors Association, 2007; National Science Board, 2007; NSF, 2003, 2010; USDE, 2011).

The findings of several studies have consistently shown that student engagement, when correlated with STEM learning, highlights the fact that minority groups are underrepresented in STEM disciplines when compared to Whites with similar abilities, and that students from minority groups lag behind in achievement (AAAS, 2011; Business-Higher Education Forum, 2011; Gonzalez, 2012; Greene et al., 2006; Hayden et al., 2011; Tsui, 2007; U.S. Congress Joint Economic Committee, 2012).

The use of a goal-based approach can help ensure improvement within a STEM program by addressing alternative issues such as equity and social justice that are associated with engagement and STEM learning. With the goal-based model, the evaluator will be able to prescribe what improvements are to be made by all stakeholders for the program's successful implementation. For example, using the educative, values-engaged approach to evaluate a STEM program will describe how historical factors affect the quality of students from minority groups and prescribe the necessary measures to address those issues.

Utilizing the goal-based model in evaluating the pedagogy of a STEM science program, Cheng et al. (2009) noted that while the program was among the best in the nation, it was not sensitive enough toward gender and ethnic/racial diversity. However, the educative, values-engaged approach allowed the researchers to prescribe that certain things, such as training during the summer on essential equipment and improving the quality of the mentorship program, be provided for underrepresented groups that are part of the STEM program. Evaluation approaches are largely prescriptive by giving specifications on what a good or proper evaluation is and how the evaluation should be conducted. There are sets of rules, prescriptions, prohibitions, and guiding frameworks to be followed. The educative, values-engaged approach is among those theories of evaluation practices that address such enduring themes as how to understand the nature of complex issues, how to assign value to programs and their performance, how to construct knowledge, and how to use the knowledge generated by the evaluation (Greene et al., 2006; Worthen et al., 1997).

According to Greene et al. (2006), the educative, values-engaged approach looks beyond the tasks of program design and methodology and seeks to address engagement associated with diversity and equity among underserved minority groups. These are critical values that are closely linked to teaching and learning in STEM educational programs. However, the disadvantage is that some stakeholders will question the need to address certain auxiliary issues such as equity and social justice, and evaluators are left with the task of convincing them. Also, it can be difficult to present the findings to multiple audiences especially when the resulting decision infringes upon stakeholders' status or position (AAAS, 2011; Boulmetis & Dutwin, 2005; Greene et al., 2006; Hall et al., 2012).

Summary

The purpose of this chapter was to provide the reader with an understanding of the constructs of this study. Choosing the right theoretical framework and approach to conduct program evaluation study allows the researcher to describe clearly the connections that exist between processes and activities with program outcomes that are necessary to provide information for making improvements to the Griffin High School Integrative STEM Academy (Boulmetis & Dutwin, 2005). The formative evaluation process involves a comprehensive assessment of activities and processes that influence the program outcomes. Three evaluation models that were used to conceptualize the tasks on which the program evaluation study was based were presented. This will allow stakeholders to make assumptions about the program based on the data that were collected. According to Jolly et al. (2004), engagement, capacity, and continuity (the ECC trilogy) are program outcomes that represent successful STEM learning. The development of the ECC trilogy was based on several studies of achievement in STEM-related disciplines (Board of Regents of the University of Wisconsin System, 2008; Boe et al., 2011; Carnevale et al., 2011; Jolly et al., 2004; Rockwell & Bennett, 2004). Jolly et al. suggested that STEM evaluation should include measures of all three factors in order to monitor the change necessary for successful improvement of the program.

CHAPTER 3

METHODOLOGY

The purpose of this study was to conduct a formative program evaluation of the Spalding County–Griffin High School integrative STEM Academy. The discrepancy model was used to evaluate the Griffin High School Integrative Academy using. By employing the discrepancy model (McKenna, 1981) approach in this formative program evaluation, the researcher identified differences between the Griffin High School STEM program and highly successful STEM programs that are meeting the U.S. STEM goals (NRC, 2011). Using the ECC trilogy as a measure, this comprehensive evaluation study not only revealed information about the value of what the program offers but also evaluated those contextual factors (i.e., gender, socioeconomic status, ethnicity/race) that will either hinder or support the degree to which an individual will commit to continue in the STEM Academy and beyond (Greene et al., 2006). For example, in an evaluation of a newly implemented integrative STEM program in one high school, researchers found that students from certain racial and ethnic groups struggled to gain success and remain in STEM programs when compared to other groups of students (Hays, 2004). Studies have also shown that even with a state-of-the-art STEM program, if the how and why questions are not understood and if stakeholders cannot define success of STEM learning, the value of the program may not be effective (Communities Foundation of Texas, 2013; NRC, 2011; National Science Board, 2007). Moreover, studies have demonstrated that successful STEM learning is measured by three interdependent factors, one of which is engagement (Greene et al., 2006).

According to Martinez (2005), conducting program evaluation on a regular basis can greatly improve the management and effectiveness of an organization and its programs. Therefore, instead of waiting until the end of a long period to determine the success of a program, this formative evaluation study will allow for more short-term adjustments based on findings.

The purpose of this study was to conduct a formative program evaluation of the Griffin High School integrative STEM education program to identify areas that need improvement. According to Boulmetis and Dutwin (2005) and Stufflebeam (2001), program evaluations are necessary to help ensure the successful implementation of educational programs which includes the STEM initiative. Furthermore, this study will enable the Griffin High School integrative STEM program to meet established national STEM goals for the students and community.

Research Questions

The following research questions guided the study:

1. To what extent does engagement (i.e., behavioral, emotional, and cognitive) exist in the Griffin High School integrative STEM Academy for all students, including socioeconomic status, gender, and ethnicity/race?
2. To what extent does capacity (i.e., achievement) exist in the Griffin High School integrative STEM Academy for all students, including socioeconomic status, gender, and ethnicity/race?
3. To what extent does continuity (i.e., enrichment, support, access for growth and development) exist in the Griffin High School integrative STEM Academy for all students, including socioeconomic status, gender, and ethnicity/race?

4. To what extent do engagement, capacity, and continuity exist in the Griffin High School integrative STEM Academy from the teacher's perspectives?
5. To what extent does continuity exist in the Griffin High School integrative STEM Academy from the parent's perspectives?
6. To what extent does continuity exist in the Griffin High School integrative STEM Academy from the administrator's perspectives?

Program Evaluation

The justification for conducting a formative program evaluation was based on the concept that it aids in determining the value of instructional activities, effectiveness of the processes (e.g., recruiting students, recruiting teachers, selecting teaching resources, etc.), and impact of the learning experience on stakeholders and the organization (Boulmetis & Dutwin, 2005; Stufflebeam, 2001).

The goal of this evaluation was to determine the effectiveness of the Griffin High School integrative STEM Academy. This evaluation investigated areas of for the Griffin High School STEM program based on a STEM blueprint established on criteria from successful STEM programs across the country. The evaluation process began with a preplanning activity in order to gather background information about the Griffin High School integrative STEM program in preparation for the design phase.

Design

This program evaluation study was conducted using the descriptive research design. This design approach allowed the researcher to use multiple data collection instruments to provide supporting data for the conclusions that were reached. Conceptualized multiple constructs of integrative STEM education were reviewed using STEM-related literature. Although describing effective STEM practices and successful STEM outcomes and collaborating with site-based stakeholders may be complex, such collaboration when conducting field research is important..

Multiple Sources

In order to answer evaluation questions, instruments employing descriptive research methods were used for data collection from multiple sources. The quantitative data were collected from a review of school records that included statewide end-of-course test (EOCT) scores, students' attendance records, demographic data, and survey questionnaires related to student interests in STEM disciplines, along with the views of parents, students, and teachers regarding the integrative STEM program. For example, indicators of student engagement in STEM disciplines, as it relates to Research Question 1 (To what extent does engagement (i.e., behavioral, emotional, and cognitive) exist in the Griffin High School integrative STEM Academy for all students, including socioeconomic status, gender, and ethnicity/race?) are outcomes that can be determined from attendance records (NRC, 2011) or instruments measuring interest in STEM disciplines (CEISMC, 2012).

In order to provide information that will lead to a more comprehensive improvement of the integrative STEM Academy, multiple data sources can provide a more powerful picture of the changes to be made. According to Bernhardt (2004), multiple measures include not just student achievement but also demographics, perceptions, and school processes. Demographics provide information about the school community, such as enrollment, attendance, grade level, ethnicity, and gender. Perceptions provide information through questionnaires to understand what students, parents, teachers, and administrators think about the integrative STEM learning environment being created. School processes as it relates to the integrative STEM Academy involves the instructional strategies and classroom practices that are being implemented

(Bernhardt, 1998). Information was extracted from intersections of the multiple measures, which allowed the study to provide better answers to the questions.

Population

The study was conducted at Griffin High School of the Griffin-Spalding County School System in Georgia. Griffin High School is located in the metropolitan Atlanta area, approximately 50 miles south of Atlanta. The student population at the school is made up of diverse gender, socioeconomic and ethnic/race groups that were factored into the analysis. Therefore, demographic data were collected in this study. Studies have indicated that minority groups and women are underrepresented in STEM fields (Boulmetis & Dutwin, 2005; Hays, 2004). Efforts to increase the presence of minorities in STEM education are crucial to the economic health of the United States (NRC, 2011). The demographic data in Table 2 is a breakdown of the student population of Griffin High School.

The Griffin High School student population is divided into three main academies based on their academic preferences, which is grounded on the small learning community concept. The three academies are (a) the Integrative STEM Academy, (b) the Consumer Science Academy (related to health and political science fields), and (c) the Visual and Performance Arts Academy (related to music, art, audiovisual technology, and communication). The integrative STEM Academy started with the selection of approximately 60 students who exhibited high interest in STEM fields (as suggested by Griffin High School STEM teachers). Admission into the integrative STEM program is based on teacher recommendations and student’s interest. Data were collected from Griffin High School teachers and administrators who are involved with the integrative STEM Academy. Also, information was collected from parents of students in the STEM Academy.

Table 2

Griffin High School Demographic Data

Student data	2012–2013	% of student enrollment
Grade 9–12 total enrollment (male + female)	1,282	100.00
Female		
Hispanic	32	2.50
Black	336	26.21
White	248	19.35
Asian	7	0.55
Mixed (2 or more races)	13	1.01
Native American	2	0.16
Total	638	49.77
Male		
Hispanic	49	3.82
Black	349	27.22
White	232	18.10
Asian	8	0.62
Mixed (2 or more races)	13	1.01
Native American	1	.08
Total	644	50.23
Ethnic group (male + female)		
Hispanic	81	6.32
Black	685	53.43
White	480	37.44
Asian	15	1.17
Mixed (2 or more races)	26	2.02
Native American	3	0.24
Free lunch	913	68.00
Reduced lunch	116	8.64

Note. Adapted from *School Report Card* by Georgia Department of Education, 2011, Copyright 2011 by Georgia Department of Education.

Of the 60 students who initially enrolled in the Griffin High School integrative STEM Academy, 47 completed one full year. According to the teachers, students primarily exited the academy to get into classes that were mandatory for graduation requirement. Of the approximately 47 enrolled students, 20 (14 male, 6 female) returned signed parental permission and assent or consent forms and volunteered to participate in the study. The race/ethnicity makeup of these students included 40% African American, 50% White, 5% Native American, and 5% ethnicity undisclosed. One of the three teachers that three teachers was participant in the study. One teacher retired and other was unavailable during the time for data collection. There was one parent participant and one administrator (i.e. the principal) participant that participated in this study.

Instrumentation

Direct links to the activities and processes of a program and influences on their outcomes can be understood using the evaluation process (Gall et al., 2003). Choosing appropriate instrumentation to uncover the underlying evidence necessary to develop an effective program is essential (Campbell & Borgen, 1999). James Bell Associates (2009) emphasized the need for alignment of program data in a program in which improvements need to be made. In order for an integrative STEM program to be successful, Greene et al. (2006), Jolly et al. (2004), and the NRC (2011) suggested three broad interdependent factors be used as the judging criteria for success: engagement, capacity, and continuity, which are to be aligned with the choice of instruments for valid and reliable data collection.

The terms *validity* and *reliability* are widely used in the field of research in association with data collection instruments. Gloeckner et al. (2001) noted that the term *validity* is used by researchers to ask if the research really measures what it is supposed to measure, while *reliability* asks about the consistency of the measurement. This means an instrument may not be valid because it does not fulfill the purpose for which it was selected and the data will not be in sync with the constructs. On the other hand, it is reliable because it generates data whenever it is in use (Cronbach & Meehl, 1955; Messick, 1995; Moss, 1998; Reckase, 1998). Table 3 depicts the specific types of quantitative outcome data collection instruments used in this study.

Table 3

Types of Measures for Outcomes

Outcome	Sample	Instrumentation
Engagement	Students and Teachers	Questionnaires Discipline referral records
Capacity	Students and Teachers	End-of-course test scores (if available) Course/test scores Questionnaires
Continuity	Students, Teachers, Parents, and Administrator	Questionnaires

Validity and Reliability

In general, the terms “validity” and “reliability” refer to the extent to which data collection tools and methods provided will generate accurate, and useful information. Both are factors that should be considered in the design and selection of instruments especially for summative data collection use (Gall et al., 2003).

The concepts of validity and reliability apply primarily to summative assessment, and not as directly to formative assessment, because instructor-created examinations and measures usually only exhibit “face validity,” and they are not usually subjected to rigorous pre-administration tests of reliability. Content validity, and in particular “face validity,” refers to the content and structure of an evaluation instrument: On the face of it, does it appear to measure what it is designed to assess (Gall et al., 2003). In general, the content and structure of an instrument should make sense to those who are using it. The instruments used in this study have been have face validity and are similar to instruments used for several years in middle and high schools, and have gone through repeated revisions and test by designers to ensure that instruments have both content and face validity (Bernhardt, 2004). A third important form of validity is referred to as “concurrent” or “criterion validity.” Criterion validity means that an assessment instrument will yield results that are similar to those of other instruments designed to assess the same outcome (Gall et al., 2003).

Reliability refers to the consistency of results for a test or assessment instrument over repeated administrations to the same individuals. For example, the continuity assessment given twice to the same student, should yield similar results each time. Reliability information is usually presented in the form of statistical correlations (which should be very high) among repeated administrations of the test in the same population (Gall et al., 2003).

The use of multiple instruments allows the evaluator to gather various types of information that cannot be gained from utilizing single measures for the enhancement of data analysis. Following are several instruments suggested by researchers for the collection of program data to help evaluators understand effective changes that can be made in programs.

School Documentation

School documentation is a source of archival data that are primarily under the custody of school administrators. School documentation was reviewed for students. Examination for this study was limited to archival school data created during the implementation process (i.e., attendance records or test scores; Greene et al., 2006; James Bell Associates, 2009; Jolly et al., 2004). Standardized achievement tests are required by state law in mathematics and science courses at the end of each semester or yearlong course. Standardized end-of-course tests (EOCT) are part of the school’s evaluation program primarily in science and mathematics. If no standardized test data are available for the engineering and technology disciplines at the school, then it will not be necessary to acquire that data because, according to Carr et al. (2012) and the

ITEEA (2011), engineering and technology standards are already incorporated in science and mathematics curricula for American schools. Therefore, the EOCT scores of students who participated in the integrative STEM Academy were examined to determine what extent students were learning. According to Hays (2004), statewide standardized tests are good sources for research data as they already have proven test reliability and validity. `

School documentation was examined for information on professional development attended by teachers to increase their knowledge about the implementation of integrative STEM. To what extent are students taking AP/dual enrollment courses for the continuation of integrative STEM knowledge? School documentation will also produce information such as how attendance and demographics have changed since implementation of the integrative STEM Academy, how many students are enrolled, and how enrollment has changed.

Self-Report Questionnaires

The self-report questionnaire is one of the most common forms of instrumentation for the collection of data (Gall et al., 2003). The data from a self-report instrument draws responses from the participants and provides information the evaluator would not be able to personally observe. Self-report questionnaires allow for dichotomous [yes/no] responses and Likert-scale responses. Several self-report instruments were used for this study to collect data from students, parents, teachers, and administrators. These self-report instruments are discussed in the following sections.

Survey (or questionnaire) research has its advantages and disadvantages. According to Hill (2001), questionnaires can be used at relatively low cost, particularly when they are authored by the researcher. Surveys make data collection more manageable especially if there are institutional, geographic, and sensitive barriers to overcome. Some disadvantages include "limitations on the type of data that can be collected and adverse respondent attitudes towards providing requested data" (Pedhazur, 1997, p. 203). Long or complex questionnaires may not be the right fit for respondents and may lead to the collection of inaccurate data. Another disadvantage is that questionnaires can be too limiting and result in incomplete or inaccurate data collection. There is also little or no opportunity for follow-up responses.

STEM Semantics Questionnaires

The STEM Semantics Questionnaire (Appendix A) was given to the 20 student participants used to measure engagement. The STEM Semantics Questionnaire primarily collects information about student interest (engagement) in individual STEM disciplines and in STEM careers. The STEM Semantics Questionnaire, a brief, reliable, and construct-valid instrument, maintains an education-friendly, Likert-type format. It has been used in previous STEM research (Tyler-Wood et al., 2010). It uses a 7- point Likert-type scale, ranging from 1 to 7 between pairs of opposing words. According to Kier, Blanchard, Osborne, & Albert, (2013), there is no statistically significant difference in the mean scores of a 5- and 7-point mean scores when both were used for the same set of questions. However, a 7-point Likert scale is chosen to help respondents be less neutral. The 7-points are used between opposing words. For example, students rate on a 7-point Likert scale if they feel technology is better described as appealing (1) or unappealing (7). The STEM Semantics Questionnaire has internal consistency reliability ranging from .78 to .94 across the eight constructs, and an assed validity that ranged from .84 to .93 for all areas.

Student Questionnaires

1) The student questionnaire in Appendix B was used to address concerns for program improvement (Jolly et al., 2004). 2) The survey consists of a Thurston scale brief and reliable

format that allows the student to respond in a favorable or unfavorable manner. 3) This instrument addresses include the views of students (positive, negative, or indifferent) regarding the opportunity for them to continue their studies in STEM disciplines. 4) A modified version is presented in Appendix B. 5) An organization named, Education for the Future used these questionnaires from 1991 to 2004 and obtained high validity and reliability indicators (Bernhardt, 2004). According to Bernhardt, the student, teacher, and parent questionnaires are designed to collect data for school improvement.

The student survey in Appendix D consists of questions that explore students' experiences in relation to engagement, capacity, and continuity within the Griffin High School integrative STEM program. These questions were adapted from instruments that researchers have used to evaluate students' and teachers' experiences in STEM educational programs and have achieved reliable and valid results (Greene et al., 2006; National Association of Colored Women [NACW], 2010). Responses to the questions were expected to provide information on the extent to which the processes and activities of the Academy are supporting students' STEM engagement, capacity, and continuity. According to Bernhardt (2004), measuring processes is one of the most important things one can do to improve integrative STEM education programs. The processes have extensive control over educational outcomes.

Teacher Questionnaires

A teacher questionnaire in Appendix B was employed to collect continuity data which was based on Bernhardt (2004) instrument for teachers to address concerns for school improvement. The 23 item instrument included positively stated items such as, 1) I feel positive about my role as a staff member (teacher) within the STEM Academy. 2) I work with people who collaborate with each other to make student learning consistent with the national STEM goals. These are designed find areas of the integrative STEM program based on teacher perspectives, to effectively encourage students to continue in STEM disciplines. This questionnaire assesses the extent to which teachers perceive themselves, administrators, and parents working in unity to support a continuum of integrative STEM learning that makes sense for students, and to create an environment to increase student achievement.

The teacher questionnaire in Appendix D consists of questions that explore teacher experiences in relation to engagement, capacity, and continuity within the Griffin High School integrative STEM program. These questions were adapted from instruments researchers have used to evaluate students’ and teachers’ experiences in STEM educational programs and have achieved reliable and valid results (Greene et al., 2006; Jolly et al., 2004; NACW, 2010). Responses to the questions were also expected to provide information on the extent to which the processes and activities of the Academy are supporting students’ STEM engagement, capacity, and continuity. According to Bernhardt (2004), measuring processes from the teacher perspective will show the extent to which teachers are working together to create quality STEM learning for all students, and if there is a shared vision with administrators who may or may not be supportive of the integrative STEM Academy.

Parent Questionnaire on Continuity Outcomes

The parent questionnaire (Appendix B) is a self-report questionnaire used to address concerns for program improvement (Bernhardt, 2004). The instrument was used to collect information about the Griffin High School Integrative STEM Academy’s potential for continuity outcomes to support STEM development. Studies have revealed that parental involvement and parents’ ability to help their children learn increases the more they know about school programs and feel welcome at the school (Bernhardt, 2004; Jolly et al., 2004; NACW, 2010). Therefore, this questionnaire was used to determine to what extent parents are involved.

STEM Program Administrator Survey

The administrator survey (Appendix C) is a self-report questionnaire used to reflect the respondent's views about the integrative STEM program's ability to provide opportunities for student continuity. It was designed to help ascertain the extent to which school administrators are providing leadership in support of the integrative STEM Academy. Their information will also help to address concerns for overall improvement (Bernhardt, 2004) of the integrative STEM Academy to effectively encourage students to continue in STEM disciplines. The role of administrators as stakeholders is vital for the successful development of the integrative STEM program.

Subscales

According to Yu (2012) subscale on an instrument can be identified when items are going in the same direction, whether or not the items are positive statements or negative statements. There must also be common variability (i.e. a common theme) of items within a subscale. On this basis, some items on certain instruments were determined to have common themes and were also in the same direction. Base on definitions of the ECC trilogy outcomes each outcome has multiple themes or components that also made it better to identify subscales. For example, engagement has different characteristics such interest (i.e., likes, dislikes, or indifferent) towards something, motivation to act based one ones emotion). Therefore the items of each instrument take into account the varied ways the each outcome can be defined. For example, on the engagement items (2) My behavior (discipline) has improved because of integrative STEM, and (3) The behavior (discipline) of my classmates improved as a result of this (integrative STEM) program, are opinions the behavioral component of engagement, thereby forming a subscale of the instrument.

Procedures

To accomplish the purpose of this program evaluation study, the researcher sought approval to conduct the study from the University of Georgia's Institutional Review Board (IRB, Human Subjects) (See Appendix A for IRB approval to conduct study obtained on May 12, 2014) and the participating school system, Griffin-Spalding County School System (See Appendix A Griffin-Spalding County School System approval to conduct study received on May February 28, 2014). After receiving approval from the IRB and school system, consent forms were supplied to participating students and their parents, along with a cover letter to inform participants of the purpose, significance, confidentiality, and time frame of the study. Upon receipt of participants' consents, they were invited to complete multiple instruments (see Appendices C–F). The approved parental, consent, and assent forms are shown in Appendix B that parents, students, teachers, administrations were able to get directions and their agreements to participate in study. As several types of participants (i.e., students, teachers, administrators, and parents) were involved, specific times were assigned for specific participants during a specific week in May 28 to June 06, 2014. Each questionnaire took 10–20 minutes to complete.

The data collection process was scheduled to occur at a time convenient to the participants based on school operations within a period of 4–10 days. A request was made for school administrators to provide the researcher access to archival data, which included attendance records, achievement tests scores, and demographics data (with coded identification of subjects). The self-report instruments used for collecting data were presented in online format. Time and location were specified for consenting participants to complete the self-report instrument in a Griffin High School computer lab. Six students returned signed parental permission forms and signed assent forms after five days of recruitment they were allowed to participate on May 28, 2014 during the homeroom period from 9:50 AM to 10:10 AM in a computer lab. The recruitment (i.e., continued announcements) continued for another three days and 11 more students returned their forms and were allowed to participate on June 02, 2014 during the homeroom period from 9:50 AM to 10:10 AM in a computer lab. After three more days of recruitment three more students returned their signed forms and participated on June 06, 2014. Data analysis began following the collection of all data. Data analysis was done quantitatively. A program evaluation of the implementation processes within the school was based on the discrepancy model proposed for this study. Each evaluation question was addressed along with a description of evaluation processes and methodology and data analysis methods

Data Analysis

The quantitative data were analyzed through multiple data analysis procedures. The use of multiple data sources helped to provide a deeper understanding of the outcomes of the integrative STEM program and their effects. The data were analyzed together within and across cases to provide meaningful understandings. Gall et al. (2003) suggested that utilizing theory-in-action procedures helps to reduce discrepancies in what the collected data indicate about a program and the theory that is established regarding U.S. STEM criteria from successful STEM programs across the nation (NRC, 2011). The analysis of the data using quantitative methods was done to determine frequencies and significance of the data.

Based on the nature and purpose of this program evaluation, the researcher determined that several quantitative analysis procedures would be utilized. The researcher examined the scores from the program outcomes (engagement, capacity, and continuity) as a function of student ethnicity based on four ethnic groups: Asian, Black, Hispanic, and White. Table 3 depicted the multiple scores that represent outcomes of engagement, capacity, and continuity.

Therefore, each score (dependent variable) was analyzed in relation to gender, race/ethnicity, or socioeconomic status. For example, if the dependent variable is EOCT score as a function of socioeconomic status, a suitable analysis procedure will be selected.

According to Gall et al. (2003), multiple regression involves the use of correlation between two or more predictor variables and criterion variables. A high correlation ($R \geq .7$) signifies strong correlation. Multiple regression is also suitable for quantitative research analysis and “can handle interval, ordinal, or categorical data. And it provides estimates both of the magnitude and statistical significance of relationships between variables” (Pedhazur, 1997, p. 340). The mathematical representation of multiple regression is expressed as

$$\hat{Y} = b_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + \mathrm{C}$$

where X represents the potential predictor variables, while b represents the “regression weight” (Pedhazur, 1997, p. 345) that varies from –1 to +1. The criterion variable ($\hat{Y}$) is determined by a given scale, and the predictor variables (X_i) is analyzed using multiple regression diagnostic procedures.

Additionally, the quantitative data were analyzed by using descriptive statistics (mean [*M*], standard deviation [*SD*], range, and percentage) to ascertain if there are differences among the scores yielded by each instrument for the different student groups that participate in the Griffin High School integrative STEM program. Descriptive statistics were used for each independent variable of gender, socioeconomic status, and race/ethnicity to show statistical variability in the outcomes (engagement, capacity, and continuity) to reflect degree of effectiveness of the integrative STEM program.

Multiple regression analysis also included preliminary colinearity and influential diagnostics, which helped determine the variables. The full model of factorial design was used to analyze quantitative data using the multiple regression design method as prescribed by Gall et al. (2003). Second, multiple regression analysis was carried out in this study to determine if there are statistically significant differences between the mean scores. The data analysis procedures included the following.

Table 4

Structure of the Engagement Data Variables

Variable name	Description
STUDENT	Student ID
FEMALE	Gender
ETHNIC	Ethnicity
SES	Socioeconomic status
ATTEND	Attendance
STEM	STEM interest
AP	AP courses/dual enrollment

In response to Research Question 1, data related to the engagement construct were of interest. To analyze the engagement construct, different data sources from program outcomes were involved that reflect behavioral, emotional, and cognitive levels of engagement. Archival school data as an indicator for cognitive engagement in STEM disciplines quantitatively reflect the number of students taking AP classes. Second, as an indicator of behavioral engagement, students' discipline records were obtained through a review of archival school records for engagement data. Third, the indicator of emotional engagement was a measure of student interest using a self-report instrument of integrative STEM disciplines. Descriptive statistics were used to summarize the data with statistics characteristics such as the means and standard deviations of the collected data groups in the STEM Academy. Multiple regression analysis tested for significant differences among the group means. Table 4 shows the structure of the engagement data variables.

In response to Research Question 2, data related to the capacity construct were of interest. To analyze the capacity construct, this evaluation took into consideration student achievement, (Hays, 2004), in math and science based on end-of-course results. These scores reflected students' STEM knowledge which is indicator of the development of capacity. Achievement was assessed through the archival school documents using EOCT and/or teacher records. The integrative STEM curriculum was compared with national STEM curriculum standards alignment based on the Standards for Technological Literacy (developed by the ITEEA), Principles and Standards for School Mathematics (developed by the NCTM), Project 2061, and Benchmarks for Science Literacy (developed by the AAAS; ITEEA, 2011). Professional development information was obtained using teacher questionnaire. Multiple regression analysis tested for significant differences among the group means of student subgroups. Table 5 shows the structure of the capacity data variables.

Table 5

Structure of the Capacity Data Variables

Variable name	Description
STUDENT	Student ID
FEMALE	Gender
ETHNIC	Ethnicity
SES	Socioeconomic status
EOCT	End-of-course test
PD	Teacher professional development
AP	AP courses/dual enrollment

In response to Research Question 3, data related to the continuity construct were of interest. Continuity takes into account the need for STEM program to provide knowledge and skills from one level to another, and to foster high level of engagement in learning. There are several characteristics that can be used as measures of continuity that include support from community, parents, mentors, opportunities provided for students to enrolled in advanced classes, extra-curricular activities. To analyze the continuity construct, the evaluation took into consideration whether the program is providing high-quality STEM learning opportunities, the degree of parent–community involvement, and the degree to which there is a STEM culture that promotes students' STEM learning beyond high school (Hays, 2004). Table 6 shows the structure of the continuity data variables.

Table 6

Structure of the Continuity Data Variables

Variable name	Description
STUDENT	Student ID
TEACHER	Teacher ID
PARENT	Parent ID
ADMIN	Administrator ID
FEMALE	Gender
ETHNIC	Ethnicity
SES	Socioeconomic status
SISTEMV	Student integrative STEM views
TSTEMV	Teacher integrative STEM views
PSTEMV	Parent integrative STEM views
ASTEMV	Admin integrative STEM views
STEM	STEM interest
AP	AP courses/dual enrollment

Table 7 represents a summary of the overall quantitative data analysis that was used in this study. Information was obtained from multiple data sources, including archival school data and student/teacher questionnaires that were analyzed in order to improve the Griffin High School Integrative STEM Academy.

Table 7

Quantitative Data Analysis

Research question	Variables	Form	Statistics
1. To what extent does engagement (i.e., behavioral, emotional, and cognitive) exist in the Griffin High School integrative STEM Academy for all students, including socioeconomic status, gender, and ethnicity/race?	Engagement: AP courses, attendance, interest Gender: female, male Socioeconomic status (SES) Ethnicity: Hispanic, Black, White, Asian, other	Continuous 0–100	• Descriptive • Multiple regression
2. To what extent does capacity (i.e., achievement) exist in the Griffin High School integrative STEM Academy for all students, including socioeconomic status, gender, and ethnicity/race?	Capacity: EOCT scores, professional development Gender: female, male Socioeconomic status Ethnicity: Hispanic, Black, White, Asian, other	Continuous 0–100 Categorical	• Descriptive • Multiple regression
3. To what extent does continuity (i.e., enrichment, support, access for growth and development) exist in the Griffin High School integrative STEM Academy for all students, including socioeconomic status, gender, and ethnicity/race?	Continuity: AP courses, dual enrollment, co-curricular activities Gender: female, male Socioeconomic status Ethnicity: Hispanic, Black, White, Asian, other	Continuous 0–100 Categorical	• Descriptive • Multiple regression
4. To what extent do engagement, capacity, and continuity exist in the Griffin High School integrative STEM Academy from the teacher's perspectives?	ECC trilogy Gender: female, male Ethnicity: Hispanic, Black, White, Asian, other	Continuous 0-100 Categorical	Descriptive
5. To what extent does continuity exist in the Griffin High School integrative STEM Academy from the parent's perspectives?	Continuity Gender: female, male Ethnicity: Hispanic, Black, White, Asian, other	Continuous 0-100 Categorical	Descriptive
6. To what extent does continuity exist in the Griffin High School integrative STEM Academy from the administrator's perspectives?	Continuity Gender: female, male Ethnicity: Hispanic, Black, White, Asian, other	Continuous 0-100 Categorical	Descriptive

Summary

There is a need to develop effective STEM programs to enable the United States to maintain its global leadership position and to improve the human condition of its citizens. A variety of STEM instructional programs are being introduced and employed in schools throughout the nation. Some show promise with regard to their effects with students, while others seem to be little more than window dressing for schools and systems. The ability to evaluate these STEM programs is essential to make any accurate form of determination regarding their educational value. Program evaluation techniques are necessary tools to help to identify and address areas of concern that are crucial for the implementation of effective STEM educational programs.

The methodology for this study was designed to gather information from program outcomes that indicated the effectiveness of the processes and activities used at the integrative STEM Academy at Griffin High School. Appropriate theories and models were employed to ensure that the collected information adequately addressed the questions designed to facilitate the necessary integrative STEM improvements. Multiple instruments for collecting quantitative data were used in this study in order to provide credible and meaningful data. Appropriate data analysis methods, such as descriptive statics and multiple regression, were used in this study.

CHAPTER 4

RESULTS

The purpose of this study was to conduct a formative program evaluation of Griffin High School Integrative STEM Academy in order to identify areas that can improve teaching and learning. Essentially, the study was designed to determine if there were perceived differences in STEM learning of the Griffin High School Integrative STEM Academy and STEM learning across the nation's highly successful STEM schools and programs. According to the NRC (2011) study entitled, Successful K12 STEM Education highlighted effective programs and practices across the country that are linked to successful program outcomes (e.g., test scores, advanced placement [AP] courses taken, etc.). The researcher has several similar factors (e.g., socioeconomic status, race/ethnicity, gender) that did not significantly affect students in successful STEM programs. For example, in the Texas' 51 inclusive STEM schools score were slightly higher on the state mathematics and science achievement tests for enrolled students,

The dependent variables included three kinds of STEM outcome characteristics: engagement, continuity, and capacity, also known as the ECC trilogy. Engagement outcome was determined using discipline records and questionnaires (i.e., Student Semantics STEM Questionnaire in Appendix A, Student ECC Outcome Questionnaire [Engagement QUs 1-6] in Appendix D, and Teacher ECC Outcome Questionnaire [Engagement QUs 1-5] in Appendix D).. Capacity outcome was determined using and EOCT (i.e., mathematics and science) scores and questionnaires (i.e., Student ECC Outcome Questionnaire [Capacity QUs 1-3] in Appendix D, and Teacher ECC Outcome Questionnaire [Capacity QUs 1-6] in Appendix D. Continuity outcome was determined using questionnaires i.e., Student, Teacher, and Parent Questionnaires in Appendix B. Administrator Continuity Questionnaire in Appendix C. Student ECC Outcome Questionnaire [Continuity QUs 1-5] in Appendix D, and Teacher ECC Outcome Questionnaire [Continuity QUs 1-6] in Appendix D). The independent variables for this study were gender, race/ethnicity, and socioeconomic status. To be a highly successful STEM program, the Griffin High School Integrative STEM Academy must meet the criteria of providing engagement, capacity, and continuity in STEM disciplines for participating students.

This chapter presents a description of the sample and the results of the analysis conducted to address each of the research questions. Descriptive statistics for each of the dependent variables from respective sets of data were used to address each research question. Multiple regression analyses were conducted for assessing the effect of each independent variable on each of the dependent variables, using a convenience sample of $n = 20$ and an alpha level of .05.

Description of Samples

The samples for this study were limited to the administrators, parents, teachers, and student participants of the Griffin High School Integrative STEM Academy. Student participants in the Academy dropped from 60 to 47 at the end of the Spring 2013 semester. One of the three staff members who started the Academy retired at the end of the 2012–2013 school year. The samples of this study included 20 (14 male, 6 female) student participants. The race/ethnicity makeup of these students included 40% (n=8) Black or African American, 50% (n=10) White, 5% (n=1) Native American, and 5% (n=1) ethnicity not identified. One teacher, one parent, and one administrator (i.e. the principal) participated in the study. After approval was received from the Spalding-Griffin School District administration and the University of Georgia’s IRB to conduct this study, the Griffin High School Integrative STEM Academy participants were recruited for the study.

Three teachers were involved in the Griffin High School Integrative STEM Academy, one of whom retired at the end of the 2012–2013 school year. One of the remaining staff members participated in the staff survey. All 47 students received recruitment packet with consent forms to invite parents to participate in study. One parent responded to the parent questionnaire. The administrator questionnaire was completed by the one administrator.

Results Specific to the Research Questions

This section provides the results for each research question for this study. Both the questionnaire instruments and student archival school data were used as multiple data sources to generate the results required to answer each research question. The instruments used in this study were designed to measure outcomes as described by the ECC trilogy.

The student instruments consisted of questions using positive statements about factors related to engagement, capacity, and continuity outcomes, divided into multiple subscales. The first three questions to determine gender, race/ethnicity, and socioeconomic status are independent variables. The items of the Student Continuity Questionnaire, Appendix B yielded responses that represent dependent variables for how students rate continuity outcome provided by the Griffin High School community. The items were scored on a Thurston 3-point scale (*yes*, *no*, and *I don't know*). All of these items except for one were written in the positive, that is, *yes* reflects continuity. Items of the Student ECC Outcome Questionnaire, Appendix D were divided into subscales that represent dependent variables for how students rate engagement (Questions 1–6), capacity (Questions 1-3), and continuity (Questions 1-5) outcomes provided by the Griffin High School Integrative STEM Academy. The subscales were scored on a 5-point scale (*strongly* *disagree* = 5, *disagree* = 4, *neutral* = 3, *agree* = 2, *strongly agree* = 1). Items of the STEM Semantic questionnaire, Appendix A were designed to measure student engagement in all four elements of STEM and were scored on a 7-point scale (each point varies from negative to positive terms or vice versa).

The teacher questionnaires consisted of questions using positive statements about factors related to engagement, capacity, and continuity outcome, divided into multiple subscales. The first two questions were designed to determine gender and race/ethnicity. Teacher Continuity Questionnaire, Appendix B yielded responses to its 15 items using positive statements represent the continuity outcome dependent variable. Teacher ECC Outcome questionnaire, Appendix D was designed with subscales for how teachers rate engagement, capacity, and continuity outcomes provided by the Griffin High School Integrative STEM Academy. The Teacher Questionnaires, Appendices B and D were scored on a 5-point scale (*strongly disagree* = 5, *disagree* = 4, *neutral* = 3, *agree* = 2, *strongly agree* = 1).

The parent questionnaire, Appendix B has a total of 15 questions using positive statements about the continuity outcome regarding the level of community involvement with the Griffin High School Integrative STEM Academy. The first question was designed to determine race/ethnicity of the parent. Questions 2–15 represent dependent variables for how parents rate continuity outcomes provided by the Griffin High School Integrative STEM Academy. The survey was scored on a 5-point scale (*strongly disagree* = 5, *disagree* = 4, *neutral* = 3, *agree* = 2, *strongly agree* = 1).

The administrator questionnaire, Appendix C has a total of 10 questions using positive statements about factors related to engagement, capacity, and continuity outcomes and is divided into multiple subscales. The first question was designed to determine race/ethnicity. Questions

2–10 are divided into subscales that represent dependent variables for how administrators rate engagement, capacity, and continuity outcomes provided by the Griffin High School Integrative STEM Academy. The survey was scored on a 5-point scale (*strongly disagree* = 5, *disagree* = 4, *neutral* = 3, *agree* = 2, *strongly agree* = 1).

Archival school data were used in the study to provide more depth to the answer for each research question. Included in the school data were the Spring 2013 EOCT scores in science and math for all respondents who were enrolled in the Griffin High School Integrative STEM Academy and the discipline referrals they received. Where there is few discipline referrals students are usually more engaged in their school activities. The passing score for the EOCT is 400, meaning that students are proficient in the subject; students exceeded proficiency if they scored 450 or higher.

Research Question 1

To what extent does engagement (i.e., behavioral, emotional) exist in the Griffin High School Integrative STEM Academy for enrolled students, including socioeconomic status, gender, and race/ethnicity are considered?

Descriptive statistics for the dependent variables are provided in multiple tables from a variety of data sources. Tables 8 provides descriptive statistics of the gender subgroups, for engagement outcome that was collected from the students enrolled from August 2012–December 2013 in the integrative STEM Academy. All mean scores were calculated by dividing the sum of observations by the number of observations. A mean score of 4.20 was calculated on a 5-point scale (1 = *strongly disagree*, 2 = *disagree*, 3 = *neutral*, 4 = *agree*, 5 = *strongly agree*). Statements on the instrument were written from a positive perspective (i.e., “I like the Griffin High School Integrative STEM Academy”). Table 9 provides descriptive statics for subgroups based on race/ethnicity. Table 10 provides descriptive statics for subgroups based on economic-status (SES). The findings from each of the subscales indicated that all of the students (100%, *n* = 20) held positive opinions of engagement. Engagement was highest for students' likes and the activities of the Academy (i.e., expressing emotional and cognitive engagement). The findings also indicated that the students were neutral on behavior (*M* = 3.20) and attendance (*M* = 3.10) perspectives (i.e., "My behavior has improved because of the integrative STEM program" and "My attendance has improved because of the integrative STEM program," respectively).

Table 8

Descriptive Statistics for Students' Opinions of Integrative STEM Academy to Provide Engagement, by Gender

	Male			Female			Total		
Subscale	%	*M*	*SD*	%	*M*	*SD*	%	*M*	*SD*
Likes	70	4.21	0.58	30	4.17	0.75	100	4.20	0.62
Activities	70	4.14	0.77	30	4.17	0.75	100	4.15	0.75
Behavior	70	3.14	0.53	30	3.33	1.51	100	3.20	0.89
Attendance	70	3.21	0.80	30	2.83	1.47	100	3.10	1.02

Table 9

Descriptive Statistics for Students' Opinions of Integrative STEM Academy to Provide Engagement, by Socioeconomic Status

	Lower SES			Upper SES			Total		
Subscale	%	*M*	*SD*	%	*M*	*SD*	%	*M*	*SD*
Likes	65	4.23	0.60	35	4.14	0.69	100	4.20	0.62

Activities	65	4.00	0.71	35	4.23	0.79	100	4.15	0.75
Behavior	65	3.15	0.99	35	3.29	0.76	100	3.20	0.89
Attendance	65	3.15	1.21	35	3.00	0.58	100	3.10	1.02

Table 10

Descriptive Statistics for Students' Opinions of Integrative STEM Academy to Provide Engagement, by Ethnicity

	Black			Native American			White			Ethnicity unknown		
Subscale	%	*M*	*SD*	%	*M*	*SD*	%	*M*	*SD*	%	*M*	*SD*
Likes	40.0	3.88	0.64	5.0	4.00	0.0	50.0	4.50	0.53	5.0	4.0	0.0
Activities	40.0	3.88	0.64	5.0	3.00	0.0	50.0	4.60	0.52	5.0	3.0	0.0
Behavior	40.0	2.88	1.13	5.0	3.00	0.0	50.0	3.50	0.71	5.0	3.0	0.0
Attendance	40.0	2.88	1.36	5.0	3.00	0.0	50.0	3.40	0.70	5.0	2.0	0.0

Multiple regression analysis tests for the independent variables that can be used to predict the dependent variable yielded the results shown in Table 11. Each of the independent variable or subgroup has its own mean value that can be compared to the mean of the other group. For example, the mean value of the opinion expressed by students of low socio-economic status maybe compared with the mean value of students who are of a higher economic-status. The process of making such comparisons using multiple regression analysis is called modelling (Pedhazur, 1997). Therefore, a model refers to the process of comparing all the group means at a level of .05 alpha that is most commonly used. If the analysis resulted at a higher significance value that alpha=.05, then the means of all the groups are not significantly different from each other. This would also signify that the independent variables did not significantly affect the dependent variables (i.e., outcomes). In this study the subgroups with means to compare were male, female lower socio-economic status (SES), upper socio-economic status, White, Black, Native American, and Not Identified Ethnicity/race. The result of model based on likes of the academy was not significant (p = .202), and yielded an adjusted R^2 value of 0.103. The result of model based on STEM activities was significant (p = .042), but it's relative close in value to the alpha of .05. The adjusted R^2 value of 0.278, which is relatively low and means that the independent only accounts for 27.8 percent of the outcome. The result of model based on behavior was not significant (p = .563), and yielded an adjusted R^2 value of -0.049. The result of model based on attendance was not significant (p = .620), and yielded an adjusted R^2 value of -0.066. The results suggested that the independent variables—gender, ethnicity, and socioeconomic status—were not predictors for the responses students gave based on their experiences while they were enrolled in the Griffin High School Integrative Academy.

Table 11

ANOVA for Student Subgroups Regarding Integrative STEM Academy to Provide Engagement

Model		*SS*	*Df*	*MS*	*F*	Sig.
Likes	Regression	1.759	3	.586	1.724	.202
	Residual	5.441	16	.418		
	Total	7.2000	19			
Activities	Regression	4.140	3	1.380	3.444	.042
	Residual	6.410	16	.401		
	Total	10.550	19			
Behavior	Regression	1.775	3	.592	.705	.563
	Residual	13.425	16	.839		
	Total	15.200	19			
Attendance	Regression	2.023	3	.674	.607	.620
	Residual	17.777	16	1.111		
	Total	19.800	19			

Note. Dependent variable: Engagement.
Independent Variables: SES, Gender, Ethnicity.

Tables 12 provide descriptive statistics that resulted from the STEM Semantics Questionnaire (Appendix A) for engagement outcome of subgroups based on socio-economic status. %). For those who answered of lower SES (65%) who received free/reduced lunch mean score was 5.95. The mean is the same, 5.95, for the of higher SES group. Table 13 records the level of engagement highest in technology among all the subgroups (i.e., socioeconomic status, gender, and ethnicity/race). For example, M = 6.21 in technology was calculated for male students (70%) and M = 5.95 for female students (30%). Table 14 presents similar results for engagement outcome of ethnicity/race subgroups. The findings also shows that positive engagement in STEM disciplines with White Students (50% of sample) had mean levels of 6.18 and 6.02 in technology and engineering, respectively. Black students (40% of sample) had mean scores of 5.75 and 5.60 in technology and engineering, respectively. The mean scores of all subgroups indicated high levels of engagement for STEM disciplines and STEM careers.

Table 12

Descriptive Statistics for Students' Opinions of STEM Disciplines and Careers, by Socioeconomic Status

	Lower SES			Upper SES			Total		
Subscale	%	*M*	*SD*	%	*M*	*SD*	%	*M*	*SD*
Science	65	5.17	1.43	35	5.23	1.08	100	5.19	1.29
Math	65	5.06	2.19	35	3.71	1.40	100	4.59	2.02
Engineering	65	5.85	1.11	35	5.71	1.00	100	5.80	1.04
Technology	65	5.95	1.39	35	5.94	1.04	100	5.95	1.25
Career	65	4.97	1.48	35	5.17	1.08	100	5.04	1.32

Table 13

Descriptive Statistics for Students' Opinions of STEM Disciplines and Careers, by Gender

	Male			Female			Total		
Subscale	%	*M*	*SD*	%	*M*	*SD*	%	*M*	*SD*
Science	70	5.46	1.10	30	4.57	1.59	100	5.19	1.29
Math	70	4.80	1.85	30	4.10	2.49	100	4.59	2.02
Engineering	70	6.10	0.88	30	5.10	1.14	100	5.80	1.04
Technology	70	6.21	1.08	30	5.33	1.51	100	5.95	1.25
Career	70	4.99	1.33	30	5.17	1.44	100	5.04	1.32

Table 14

Descriptive Statistics for Students' Opinions of STEM Disciplines and Careers, by Ethnicity

	Black			Native American			White			Ethnicity unknown		
Subscale	%	*M*	*SD*	%	*M*	*SD*	%	*M*	*SD*	%	*M*	*SD*
Science	40.0	5.23	1.45	5.0	7.00	0.0	50.0	5.06	1.20	5.0	4.4	0.0
Math	40.0	4.50	2.21	5.0	2.00	0.0	50.0	4.68	1.85	5.0	7.0	0.0
Engineering	40.0	5.60	1.21	5.0	6.70	0.0	50.0	6.02	0.83	5.0	4.20	0.0
Technology	40.0	5.75	1.20	5.0	7.00	0.0	50.0	6.18	1.27	5.0	4.20	0.0
Career	40.0	4.78	1.67	5.0	6.00	00	50.0	5.16	1.16	5.0	5.00	0.0

Multiple regression analysis tests revealed that the independent variables (i.e., gender, race/ethnicity, and socioeconomic status) significantly impacted the dependent variable of engagement outcome in STEM careers, based on students' opinions using the STEM Semantic Survey. Table 15 shows the models tested. It shows that each subgroup has different means for each subscale and for each subgroup. The result of Model 1 was not significant (*p* = .286), Model 2 was not significant (*p* = .266), Model 3 was not significant (*p* = .053), Model 4 was not significant) p = .231), and Model 5 was not significant (*p* = .804). This means the independent variables were not predictors for the views of students enrolled in the Griffin High School Integrative Academy. Table 16 shows the model summary which basically has R-squared value that provides the interpretation of the statistical measure (Pedhazur, 1997). A low R squared value indicates that independent variable explains very little of the dependent variable results.

Table 15

ANOVA for Student Subgroups Regarding STEM Engagement in Disciplines and Careers

Model		*SS*	*Df*	*MS*	*F*	Sig.
Science	Regression	6.715	3	2.238	1.384	.286[a]
	Residual	24.266	15	1.618		
	Total	30.981	18			
Math	Regression	16.155	3	5.385	1.457	.266[a]
	Residual	55.449	15	3.697		
	Total	71.604	18			
Engineering	Regression	7.052	3	2.351	3.213	.053[a]
	Residual	10.974	15	.732		
	Total	18.025	18			
Technology	Regression	5.349	3	1.783	1.268	.321[a]
	Residual	21.097	15	1.406		
	Total	26.446	18			
Career	Regression	1.709	3	.570	.329	.804[a]
	Residual	25.958	15	1.731		
	Total	27.667	18			

Note. Dependent variable: Science; Math; Engineering; Technology; Career.
Independent Variables: SES, Gender, Ethnicity.

All mean scores for engagement outcome from the teacher questionnaire (Appendix D) Items 1–5 were calculated by dividing the sum of item scores by number of items. The mean score of 4.40 was calculated based on a 5-point scale (1 = *strongly disagree*, 2 = *disagree*, 3 = *neutral*, 4 = *agree*, 5 = *strongly agree*). It was the opinion of teacher that the Griffin High School Integrative STEM Academy is providing engagement for students. This results is typical of Successful K12 Schools and Programs that were identified by the NRC, (2011) national study. This is one of the trilogy outcomes that is necessary for STEM Education program to be successful.

Table 16

Multiple Regression Analysis Results for Student Subgroups Regarding STEM Engagement in Disciplines and Careers

					Change statistics				
Model	*R*	R^2	Adj. R^2	Std. error of the estimate	R^2 change	*F* change	*df*1	*df*2	Sig. *F* change
Science	.466[a]	.217	.060	1.272	.217	1.384	3	15	.286
Math	.475[a]	.226	.071	1.923	.226	1.457	3	15	.266
Engineering	.625[a]	.391	.269	0.855	.391	3.213	3	15	.053
Technology	.450[a]	.202	.043	1.186	.202	1.268	3	15	.321
Career	.249[a]	.062	–.126	1.316	.062	0.329	3	15	.804

Note. Dependent variable: Engagement.
Independent Variables: SES, Gender, Ethnicity.

The disciplinary data of students enrolled in the Griffin High School Integrative Academy gathered from archival school data of the 2012–2013 school year also provided evidence of the engagement and capacity outcomes. The mean disciplinary score is the sum of total number of disciplinary infractions given divided by the number of enrolled students. In Table 17, it shows that the mean score of 0.5 for the student sample. This indicates that one infraction was committed per student and 50% did not receive any infractions. An assumption here is that enrolled students are engaged in STEM learning, as indicated by the low rate of infractions committed by students.

Table 17

Descriptive Statistics for Evidence of Engagement Using School Data Disciplinary Records of Students Enrolled in Griffin High School Integrative STEM Academy

	Male			Female			Total		
Subscale	%	*M*	*SD*	%	*M*	*SD*	%	*M*	*SD*
Discipline	70	0.43	0.51	30	0.67	1.0	100	0.50	0.69
	Lower SES			Upper SES					
	75	0.67	0.73	25	0	0			
	Black			White					
	45	0.44	0.73	55	0.55	0.69			

Research Question 2

To what extent does capacity (i.e., achievement level) exist in the Griffin High School Integrative STEM Academy for enrolled students including socioeconomic status, gender, and ethnicity/race?

Descriptive statistics for the capacity outcome as a dependent variable are provided in Tables 18 for socioeconomic subgroups. It shows high mean scores of lower SES (40%) was

4.31 and for higher SES (50%) was 4.35. The statements on the instrument to examine capacity outcome determined if respondents gained new knowledge and facts because of the integrative STEM program and if they obtained useful information they can apply in career choices. The mean scores were calculated for multiple subgroups on a 5-point scale (1 = *strongly disagree*, 2 = *disagree*, 3 = *neutral*, 4 = *agree*, 5 = *strongly agree*). Table 19 shows mean scores for subgroups based by gender. For example, the mean score of Black students (40%) was 4.13 and for White students (50% of sample) was 4.60. The means for both of these groups are positive. However, White had a difference of 0.47 compared to Black, representing a more positive opinion for capacity outcome offered by the Griffin High School Integrative STEM Academy. Table 20 shows similar descriptive statistics of based on ethnicity/race.

Table 18

Descriptive Statistics for Evidence of Capacity in Griffin High School Integrative STEM Academy, by Socioeconomic Status

	Lower SES			Upper SES			Total		
Subscale	%	*M*	*SD*	%	*M*	*SD*	%	*M*	*SD*
Knowledge	65	4.31	0.48	35	4.43	0.54	100	4.35	0.49
Informational	65	4.15	0.56	35	4.57	0.54	100	4.30	0.57

Table 19

Descriptive Statistics for Evidence of Capacity in Griffin High School Integrative STEM Academy, by Gender

	Male			Female			Total		
Subscale	%	*M*	*SD*	%	*M*	*SD*	%	*M*	*SD*
Knowledge	70	4.29	0.47	30	4.50	0.55	100	4.35	0.49
Informational	70	4.29	0.61	30	4.33	0.52	100	4.30	0.57

Multiple regression analysis for the independent variables that can be used to predict the dependent variable yielded the results shown in Table 21. The result of the knowledge model was not significant, with an F value = 2.475, and p = .099. An adjusted R^2 value = .189 shows that the independent variables have only minimal impact on the outcome. This means the independent variables—gender, ethnicity, and socioeconomic status—were not predictors for the responses students gave based on their experiences while enrolled in the Griffin High School Integrative Academy.

Table 20

Descriptive Statistics for Evidence of Capacity in Griffin High School Integrative STEM Academy, by Ethnicity

	Black			Native American			White			Ethnicity unknown		
Subscale	%	*M*	*SD*	%	*M*	*SD*	%	*M*	*SD*	%	*M*	*SD*
Knowledge	40	4.13	0.35	5.0	4.00	0.00	50.0	4.60	0.52	5.0	4.0	0.0
Informational	40	4.13	0.35	5.0	4.00	0.00	50.0	4.60	0.52	5.0	3.0	0.0

Table 21

ANOVA for Student Subgroups Regarding Integrative STEM Academy to Provide Capacity

Model		*SS*	*Df*	*MS*	*F*	Sig.
Knowledge	Regression	1.442	3	.481	2.475	.099
	Residual	3.108	16	.194		
	Total	4.550	19			
Career	Regression	1.580	3	.527	1.823	.184
	Residual	4.620	16	.289		
	Total	6.200	19			

Note. Dependent variable: Capacity.
Independent Variables: SES, Gender, Ethnicity.

Table 22 represents the mean scores of EOCT scores of students enrolled in the Griffin High School Integrative STEM Academy. The students' test scores were for spring of the 2012–2013 school year. In Georgia, an EOCT score of 400 is passing (student is proficient in subject), while a score of 450 or above is exceeding proficiency. The mean score for math was 408.9 and for science was 475.6. The EOCT results in Figure 4 show that most of the students enrolled in the Griffin High School Integrative STEM Academy passed both math and science and exceeded in science.

Multiple regression analysis tests for significant mean differences of the dependent variables, such as the science score, math score, and discipline referrals from the archival school data, yielded the results shown in Table 23, with three models and model summary in Table 24. The result of Model 1 was not significant (p = .566), Model 2 was not significant (p = .495), and Model 3 was not significant (p = .337). This means the independent variables—gender, ethnicity, and free/reduced lunch—were not predictors for the scores students received while enrolled in the Griffin High School Integrative Academy.

Table 22

Descriptive Statistics of School Data for Students' Math and Science EOCT Scores Regarding Integrative STEM Academy Capacity

	Lower SES (Lunch: yes)			Upper SES (no Lunch: yes)			Total		
Subscale	%	*M*	*SD*	%	*M*	*SD*	%	*M*	*SD*
Math EOCT	70	409.5	15.9	30	407.0	15.0	100	408.9	15.3
Science EOCT	70	475.14	39.7	30	477.2	37.9	100	475.6	38.3
	Male			Female			Total		
Math EOCT	75	409.3	15.7	25	407.8	15.6	100	408.9	15.3
Science EOCT	75	483.5	40.1	25	457.2	28.5	100	475.6	38.3
	Black			White			Total		
Math EOCT	45	414.1	0.35	55	404.6	15.0	100	408.9	15.3
Science EOCT	45	473.4	0.35	55	477.4	42.8	100	475.6	38.3

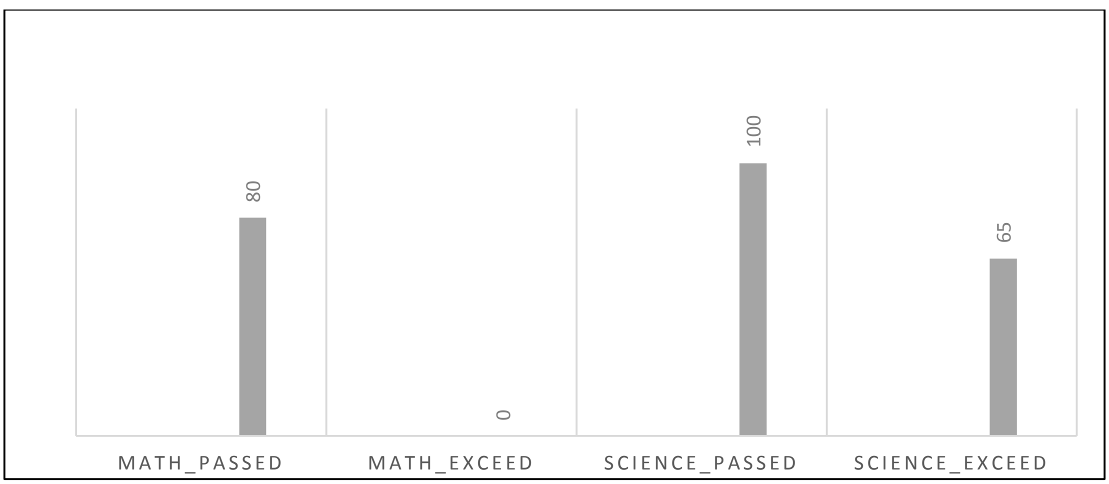

Figure 4. 2012–2013 EOCT results for students enrolled in the Griffin High School Integrative STEM Academy.

Table 23

ANOVA for Student Subgroups Regarding Mean Math and Science EOCT Scores

Model		*SS*	*df*	*MS*	*F*	Sig.
1	Regression	3223.2	3	1074.4	.699	.566[a]
	Residual	24597.6	16	1537.4		
	Total	27820.8	19			
2	Regression	599.3	3	199.8	.833	.495[a]
	Residual	3839.3	16	240.0		
	Total	4438.6	19			
3	Regression	1.7	3	0.6	1.212	.337[a]
	Residual	7.3	16	0.5		
	Total	9.0	19			

Note. Dependent variable: Capacity determined by (a) Science_Score, (c) Math_Score, and (c) Discipline. Independent Variables: SES, Gender, Ethnicity.

Table 24

Multiple Regression Analysis Results of Mean Math and Science EOCT Scores for Capacity

					Change statistics				
Model	*R*	R^2	Adj. R^2	Std. error of the estimate	R^2 change	*F* change	*df*1	*df*2	Sig. *F* change
1	.340[a]	.116	–.050	39.209	.116	.699	3	16	.566
2	.367[a]	.135	–.027	15.490	.135	.833	3	16	.495
3	.430[a]	.185	.032	.677	.185	1.212	3	16	.337

Note. Independent Variables: SES, Gender, Ethnicity.

All mean scores for capacity outcome from the teacher questionnaire (Appendix D) Items 6–11 were calculated by dividing the sum of observations by number of observations. The mean score of 3.67 was calculated based on a 5-point scale (1 = *strongly disagree*, 2 = *disagree*, 3 =

neutral, 4 = *agree*, 5 = *strongly agree*). It was the opinion of staff that the Griffin High School Integrative STEM Academy is providing capacity outcomes for the students.

Research Question 3

To what extent does continuity (i.e., enrichment, support, access for growth and development) exist in the Griffin High School Integrative STEM Academy for all students, including socioeconomic status, gender, and ethnicity/race?

Table 25 provides descriptive statistics for the continuity outcome dependent variable examined in this study of the Griffin High School Integrative STEM Academy. It shows descriptive statistics for subgroups based on socioeconomic status. Student responses for items on the instrument (see Appendix B) were based on a 3-point scale (i.e., *yes*, *no*, *I don't know*). The mean scores were calculated by dividing the total of students' scores by the number of responses. For example, Lower SES (65%) had the mean score of 5.77 of the number of times they responded *yes*. The mean score for Upper SES (35%) was 5.57. Because all of the statements except one on the instrument are written to yield positive responses (i.e., "Are there any reasons why you will not take the SAT/ACT?"), a *no* response to this item was counted as *yes*. The findings indicated that the students held more positive opinions on each of the items related to evidence of STEM continuity outcomes being provided at Griffin High School. Table 26 shows the descriptive statistics of subgroups based on gender had mean score of 5.80 for male (70%) and female (30%) had a mean score of 5.50 of overall *yes* responses to the eight items that asked if there is evidence of continuity outcome. Table 27 shows the results for subgroups based on ethnicity/race.

Multiple regression analysis tests for significance of the independent variables on the dependent variables, such as percentage of student participants with *yes* responses to positive continuity outcome statements, yielded the results shown in Table 28.

Table 25

Descriptive Statistics of Students' Opinions Regarding Continuity Provided by School Community, by Socio-economic Status

	Lower SES (yes)			Upper SES (no)			Total		
Subscale	%	*M*	*SD*	%	*M*	*SD*	%	*M*	*SD*
Yes	65	5.77	1.05	35	5.57	0.98	100	5.70	1.03
No	65	1.69	0.63	35	1.43	0.54	100	1.60	0.60
I don't know	65	0.70	0.63	35	1.00	1.00	100	0.85	0.93

Table 26

Descriptive Statistics of Students' Opinions Regarding Continuity Provided by School Community, by Gender

	Male			Female			Total		
Subscale	%	*M*	*SD*	%	*M*	*SD*	%	*M*	*SD*
Yes	70	5.80	1.05	30	5.50	1.05	100	5.70	1.03
No	70	1.60	0.63	30	1.50	0.55	100	1.60	0.60
I don't know	70	0.60	0.63	30	1.30	1.34	100	0.85	0.93

The result of Model 1 was not significant, with an adjusted R^2 value = –.14, F value = .233, and p = .872. This means the independent variables—gender, ethnicity, and free/reduced lunch—were not predictors for the scores students received while enrolled in the Griffin High School Integrative STEM Academy.

Table 27

Descriptive Statistics of Students' Opinions Regarding Continuity Provided by School Community, by Ethnicity

	Black			Native American			White			Ethnicity unknown		
Subscale	%	*M*	*SD*	%	*M*	*SD*	%	*M*	*SD*	%	*M*	*SD*
Yes	40	6.13	0.83	5.0	5.00	0.00	50.0	5.60	1.03	5.0	4.0	0.0
No	40	1.38	0.52	5.0	2.00	0.00	50.0	1.60	0.60	5.0	3.0	0.0
I don't know	40	0.88	0.99	5.0	1.00	0.00	50.0	0.80	0.93	5.0	1.0	0.0

Table 28

ANOVA for Subgroups of Students' Opinions Regarding Continuity

Model		*SS*	*Df*	*MS*	*F*	Sig.
1	Regression	.847	3	.282	.233	.872[a]
	Residual	19.353	16	1.210		
	Total	20.200	19			

Note. Dependent Variable Continuity (yes)

Independent variable: SES, Gender, Ethnicity.

Descriptive statistics for the continuity outcome as a dependent variable are provided in Tables 29 by student respondents in subgroups by socioeconomic status. The statements on the instrument to examine the continuity outcome asked respondents if this program will make them want to pursue a STEM career, if respondents have identified new resources and opportunities, and if the STEM Academy has made them change their thoughts about their career choices. The mean scores were calculated for multiple subgroups on a 5-point scale (1 = *strongly disagree*, 2 = *disagree*, 3 = *neutral*, 4 = *agree*, 5 = *strongly agree*). Table 30 shows the results descriptive statistics for the continuity outcome with the subgroups are divided based on gender. For example, a mean score for Female students (30% of sample) was 4.00 and for Male students (70% of sample) was expressed similar opinions of the integrative STEM academy to provide continuity. Table 31 shows results when subgroups are divided by ethnicity/race.

Table 29

Descriptive Statistics for Students' Opinions of Integrative STEM Academy to Provide Continuity in STEM Disciplines and Careers, by Socioeconomic Status

	Lower SES			Upper SES			Total		
Subscale	%	*M*	*SD*	%	*M*	*SD*	%	*M*	*SD*
Influence	65	2.92	1.12	35	2.43	0.98	100	2.75	1.07
Choice	65	3.31	1.18	35	4.17	0.75	100	3.58	1.12
Opportunity	65	3.77	.60	35	4.14	0.38	100	3.90	0.55

Table 30

Descriptive Statistics for Students' Opinions of Integrative STEM Academy to Provide Continuity in STEM Disciplines and Careers, by Gender

	Male			Female			Total		
Subscale	%	*M*	*SD*	%	*M*	*SD*	%	*M*	*SD*
Influence	70	2.86	.095	30	2.50	1.38	100	2.75	1.07
Choice	70	3.77	1.01	30	3.17	1.33	100	3.58	1.21
Opportunity	70	3.86	0.53	30	4.00	0.63	100	3.90	0.55

Table 31

Descriptive Statistics for Students' Opinions of Integrative STEM Academy to Provide Continuity in STEM Disciplines and Careers, by Ethnicity

	Black			Native American			White			Ethnicity unknown		
Subscale	%	*M*	*SD*	%	*M*	*SD*	%	*M*	*SD*	%	*M*	*SD*
Influence	40	3.00	1.07	5.0	3.00	0.00	50.0	2.60	1.17	5.0	2.0	0.0
Choice	40	3.50	1.41	5.0	3.00	0.00	50.0	3.89	0.78	5.0	2.0	0.0
Opportunity	40	3.88	0.35	5.0	4.00	0.00	50.0	4.00	0.67	5.0	3.0	0.0

Multiple regression analysis tests for the independent variables that can be used to predict the dependent variable yielded the results shown in Table 32. The results the models are not significant. For example, the influence model was not significant, with an F value = .711, and p = .559. An adjusted R^2 value = .118 shows that the independent variables have only minimal impact on the outcome. This means the independent variables—gender, ethnicity, and socioeconomic status lunch—were not predictors for the responses students gave based on their experiences while enrolled in the Griffin High School Integrative Academy.

Table 32

ANOVA for Student Subgroups Regarding Mean Scores of Integrative STEM Academy to Provide Continuity in STEM Disciplines and Careers

Model		*SS*	*Df*	*MS*	*F*	Sig.
Influence	Regression	2.559	3	.853	.711	.559
	Residual	19.191	16	1.199		
	Total	21.750	19			
Choice	Regression	4.044	3	1.348	1.088	.384
	Residual	18.587	16	1.239		
	Total	22.632	19			
Opportunity	Regression	.896	3	.299	.974	.429
	Residual	4.904	16	.307		
	Total	5.800	19			

Note. Dependent variable: Continuity.
Independent Variables: SES, Gender, Ethnicity.

Research Question 4

To what extent do engagement, capacity, and continuity exist in the Griffin High School integrative STEM Academy from the teacher's perspectives?

The descriptive statistics of the data yielded by the teacher ECC trilogy questionnaires are provided in Table 33. It shows at the Griffin High School integrative STEM Academy teacher expressed positive opinions that integrative STEM outcomes. From the teacher perspective, continuity seems to be the weakest of the three outcomes with a mean score of 2.71 for the responses to items on a 5-point scale (1 = *strongly disagree*, 2 = *disagree*, 3 = *neutral*, 4 = *agree*, 5 = *strongly agree*).

Table 33
Descriptive Statistics for ECC trilogy Outcome Data from Teacher Questionnaires

	# of Items	Min	Max	M	SD
Engagement Data	5	4.00	5.00	4.40	0.55
Capacity Data	6	2.00	5.00	3.67	1.21
Continuity	11	2.00	5.00	2.71	0.76

The descriptive statistics of data yielded from Teacher Continuity Questionnaire, Appendix B are provided in Table 34. The mean score of 4.71 was calculated for the responses to items on a 5-point scale (1 = *strongly disagree,* 2 = *disagree,* 3 = *neutral*, 4 = *agree,* 5 = *strongly agree*). The teacher questionnaire in Appendix B provided a more positive perspective on continuity, However, difference maybe in the construction of the questionnaires' items and may require further analysis.

Table 34

Descriptive Statistics for Continuity Outcome Survey Data From Teacher Respondents

Source	*# of Items*	Min	Max	*M*	*SD*
Staff questionnaire data	23	3.00	5.00	4.71	0.62

The respondents he responses were designed to determine how the Griffin High School Integrative STEM Academy is providing continuity support for all students. The result was *M* = 2.71 as determined by the staff responses to items on a 5-point scale (1 = *strongly disagree*, 2 = *disagree*, 3 = *neutral*, 4 = *agree*, 5 = *strongly agree*). The Parent Survey (see Appendix B) has

14 positively stated items that examined parental involvement in the Griffin High School Integrative STEM Academy. Only one respondent participated in the survey from a population of 47. However, the responses yielded a mean score of 3.86 for items on a 5-point scale (1 = *strongly disagree*, 2 = *disagree*, 3 = *neutral*, 4 = *agree*, 5 = *strongly agree*).

Research Question 5

To what extent does continuity exist in the Griffin High School integrative STEM Academy from the parent's perspectives?

The descriptive statistics of data yielded from Parent Continuity Questionnaire, Appendix B provided in Table 35. The Parent Questionnaire with nine statements on continuity outcome provided supportive data in this STEM program evaluation to help determine the effectiveness of the Griffin High School Integrative STEM Academy to provide quality STEM education. The mean score of 3.86 was calculated for the responses to items on a 5-point scale (1 = *strongly disagree*, 2 = *disagree*, 3 = *neutral*, 4 = *agree*, 5 = *strongly agree*).

Table 35

Descriptive Statistics for Continuity Outcome Data From Parent Questionnaire

Source	*# of Items*	Min	Max	*M*	*SD*
Parent questionnaire	14	2.00	5.00	3.86	0.86

Research Question 6

To what extent does continuity exist in the Griffin High School integrative STEM Academy from the administrator's perspectives?

The descriptive statistics of data yielded from Administrator Continuity Questionnaire, Appendix C provided in Table 36. The STEM Program Administrator Questionnaire with nine statements on continuity outcome provided supportive data in this STEM program evaluation to help determine the effectiveness of the Griffin High School Integrative STEM Academy to provide quality STEM education. The mean score of 3.78 was calculated for the responses to items on a 5-point scale (1 = *strongly disagree*, 2 = *disagree*, 3 = *neutral*, 4 = *agree*, 5 = *strongly agree*). This data is provides additional evidence of a positive continuity outcome from an integrative STEM program.

Table 36

Descriptive Statistics for Continuity Outcome Data From Administrator Questionnaire

Source	*# of Items*	Min	Max	*M*	*SD*
Admin. questionnaire data	9	2.00	5.00	3.78	0.97

Summary

In summary, this study examined the outcomes of the Griffin High School Integrative STEM Academy to determine if there were differences in characteristics such as gender, ethnicity, and socioeconomic status of students enrolled in the academy. Of the approximately 47 high school students enrolled in the integrative academy, 20 students received parental consent and/or volunteered to participate in the study. There were 14 male and six female students. School data showed that 75% of the student population was on free/reduced lunch, while the student respondents reported 65% were receiving free/reduced lunch. Approximately 45% of the school population are African American/Black and 55% are White. No statistically significant differences were found between the students based on their gender, race/ethnicity, and socioeconomic status.

The descriptive statistics and multiple regression analyses of the collected data as presented in this chapter indicated positive outcomes of engagement, capacity, and continuity (i.e., presented in the ECC Triology theory) that the integrative STEM academy is providing. For example, the tabulated results show high mean scores and standard deviations of participants' opinions about the integrative STEM academy in all three categories of data. The central tenant of the ECC trilogy is that the three characteristics of engagement, capacity, and continuity outcomes must exist for a STEM program in order for the STEM program to be successful. The analysis of the school archival data also yielded positive outcomes to further highlight successful integrative STEM academy outcome. For example, Figure 4 shows high passing rate in math and science for enrolled students' participants. The recorded results show no significant differences among the various subgroups distinguishable by gender, race/ethnicity, or socioeconomic status of enrolled students.

The overall results of this study is an encouraging sign showing that the Griffin High School Integrative STEM Academy has the potential to make a difference in STEM Education for all students who need a high level preparation for success in STEM disciplines and careers. The high STEM outcome characteristics shown in the tabulated results in this study are similar to the outcome characteristics of highly successful STEM programs and schools across the nation, where students are reflecting higher levels of engagement, outperforming their counterparts (i.e., capacity) who are not enrolled in well-designed STEM programs such as an integrative STEM academy, and are more likely to continue in STEM disciplines and careers beyond high school.

CHAPTER 5

DISCUSSION

This chapter begins with a summary of the study, followed by a summary of the results. In addition, conclusions and implications drawn from the results are presented for the Griffin High School Integrative STEM Academy and other STEM programs or schools that will find this study relevant to make improvements in STEM learning and instruction. Finally, the chapter concludes with recommendations for integrative STEM programs or schools and for further research.

Summary of the Study

This section provides a restatement of the rationale for the study, purpose, and research questions.

Rationale

Top priority for education today is to address the needs of all students in order to increase their proficiency in STEM disciplines. Both local and nationally, greater efforts are being made to help students to become more proficient in STEM disciplines and to prepare them for STEM careers. The NRC (2011) framework for successful implementation of a K–12 STEM program identified effective approaches and practices in schools and programs across the country that are linked to successful program outcomes (e.g., test scores, AP courses taken, etc.). As education systems across the United States are challenged to improve STEM instruction and learning toward meeting U.S. STEM goals, program evaluation is necessary for successful STEM program implementation. Based on research, criteria are established for schools to follow in order to implement and improve sound instructional practices that will better serve the needs of all students participating in STEM programs.

Several studies have shown that there is an increasing number of jobs at all levels—not just for professional scientists—that require knowledge of STEM. Meanwhile, school report cards are showing a decline in student success in STEM disciplines (Bouvier & Connors, 2011; Business-Higher Education Forum, 2011; Carnevale et al., 2011). According to the National Center for Literacy Education (2012), the success of students in STEM disciplines varies among different groups. For example, Whites generally do much better than minorities. Minorities are also largely underrepresented in STEM fields in the work force. There are indications that this deficiency in STEM disciplines begins to widen for various reasons as students continue to progress through the STEM pipeline from high school to the work force (Bouvier & Connors, 2011; Business-Higher Education Forum, 2011; Bybee, 2010; Carnevale et al., 2011; Feller, 2011).

Keeping in mind the original purpose of Griffin High School Integrative STEM Academy—develop effective STEM education programs in order to accomplish successful STEM learning outcomes in order to meet STEM national goals—the use of test scores and other data, as well as the characteristics of students from different backgrounds, including socioeconomic status, gender, and ethnicity, are linked to the operations of a program (Boe et al., 2011; Gonzalez, 2012; Hager & Smith, 2004). Therefore, these data provide a basis on which criteria can be used to monitor the implementation and improvement of successful integrative STEM programs. Collecting and analyzing outcome-related information and comparing the findings with established STEM criteria will help to ensure that concerns regarding program implementation are addressed and improvements made to successfully develop student engagement, capacity, and continuity in STEM fields (National Center for Literacy Education, 2012; NSF, 2010).

Purpose Statement

The purpose of this study was to conduct a formative program evaluation of the Spalding County–Griffin High School integrative STEM Academy in order to identify areas that can improve teaching and learning. Currently, the available literature does not offer a clear understanding of integrative STEM education (M. Sanders, 2012; Wells, 2013). Best practices and successful outcomes are indicative of how well the goals of integrative STEM programs are implemented (Jolly et al., 2004; NRC, 2011; UMass Donahue Institute, 2006). Therefore, the integrative STEM program of Griffin High School needed a formative program evaluation in order to determine the types of improvements that are necessary to promote the development of the STEM program from its current status to maturity, while at the same time meeting national goals and standards (ITEEA, 2000).

Research Questions

The following research questions guided the study:

1. To what extent does engagement (i.e., behavioral, emotional, and cognitive) exist in the Griffin High School integrative STEM Academy for all students, including socioeconomic status, gender, and ethnicity/race?
2. To what extent does capacity (i.e., achievement) exist in the Griffin High School integrative STEM Academy for all students, including socioeconomic status, gender, and ethnicity/race?

3. To what extent does continuity (i.e., enrichment, support, access for growth and development) exist in the Griffin High School integrative STEM Academy for all students, including socioeconomic status, gender, and ethnicity/race?
4. To what extent do engagement, capacity, and continuity exist in the Griffin High School integrative STEM Academy from the teacher's perspectives?
5. To what extent does continuity exist in the Griffin High School integrative STEM Academy from the parent's perspectives?
6. To what extent does continuity exist in the Griffin High School integrative STEM Academy from the administrator's perspectives?

Summary of Results

Of the approximately 60 students who were enrolled in the Griffin High School Integrative Academy, 47 completed one full year. Of the approximately 47 enrolled students, 20 (14 male, 6 female) returned signed parental permission and assent or consent forms and volunteered to participate in the study. The race/ethnicity makeup of these students included 40% African American, 50% White, 5% Native American, and 5% ethnicity undisclosed. The following paragraphs summarize the results of the study for each research question.

Research Question 1

Research Question 1 examined the degree to which Griffin High School Integrative STEM Academy is providing engagement in STEM disciplines for the students enrolled in the program. Multiple data sources generated a variety of descriptive analyses. Means and standard deviations were used to illustrate the results for the dependent variables. The data in Tables 8, 9, and10 showed that engagement (i.e., behavioral, emotional, and cognitive) does exist in the

Griffin High School integrative STEM Academy for all students, including socioeconomic status, gender, and ethnicity/race. Results indicated that the student respondents in most subgroups held positive opinions on each of the subscales related to engagement. For example, males had positive opinions on a 5-point scale with M = 4.21 for emotional engagement and M = 4.14 for cognitive engagement. Female students also expressed positive opinions with means of 4.17 for both emotional engagement and cognitive engagement. In all subgroups, student respondents did not have strong opinions of the integrative STEM academy providing behavioral types of engagement. For example, the lowest means for respondents' opinions on the attendance subscale ranged from M = 2.83 for unspecified ethnicity/race (5%) to M = 2.00 for White students (50%), and from M = 2.88 for Black students (40%) to M = 3.50 for White students (50%) on the behavior subscale.

In order to examine if any one of the student characteristics—gender, ethnicity, or socioeconomic status—would be more of a predictor than another of what student responses would be, multiple regression analyses were performed (see Table 11). With an F value = 1.724 and p = .202, the regression result was not significant, meaning there were no significant differences in student responses. A 0.103 adjusted R^2 suggested that a small percentage of the most dominant characteristics only accounted for 10.3% of responses.

A further examination of engagement was done using the STEM Semantics Survey (Tyler-Wood et al., 2010) to measure interest in STEM disciplines and STEM careers. The male respondents had mean scores that indicated high levels of engagement for the subscales: science M = 5.46, math M = 4.8, engineering M = 6.10, technology M = 6.21, and interest in STEM career M = 4.99. The female respondents also had mean scores that indicated high levels of engagement for the subscales: science M = 4.57, math M = 4.10, engineering M = 5.10, technology *M* = 6.33, and interest in STEM career *M* = 5.17. The results showed that male respondents had higher levels of engagement in the interest of STEM disciplines compared to the female respondents except in interest in STEM career. However, these differences were not significantly different based on the multiple regression results (Tables 15 and 16). The *F* values and *p* values of each subscale were as follows: science $F = 1.384$ and $p = .286$, math $F = 1.457$ and $p = .266$, engineering $F = 3.213$ and $p = .053$, technology $F = 1.268$ and $p = .321$, and STEM career $F = .329$ and $p = .804$. The regression results were not significant, with $p > .05$ level of significance for mean scores in all subscales. The adjusted R^2 values also suggested that the most dominant characteristics accounted for relatively small percentages of responses. The percentages of predictability of the independent variables based on adjusted R^2 values were science 6%, math 7.1%, engineering 26.9%, technology 4.3%, and STEM career 12.6%. Although there was no significance, it is of interest to note that in engineering, the mean differences of independent variables were almost at a significant level and can predict up to 26.9% of respondents' responses.

A questionnaire completed by teacher had a mean score of 4.40 for the number of items. The response to the teacher questionnaire expressed positive opinions that the Griffin High School Integrative STEM Academy provided high level of engagement for enrolled students.

Students' discipline referrals as a form of behavioral engagement were obtained from archival school data of respondents enrolled in the Griffin High School Integrative STEM Academy. A mean score of 0.5 and standard deviation of .69 were obtained for all respondents. The discipline referrals were very low, which correlates well with the reported opinions of high engagement levels. The multiple regression analysis of results showed no significant differences (i.e., *F* = 1.212, *p* = .337 [sig. *F* change]) of the independent variables on discipline (behavioral engagement). The adjusted R^2 of .032 indicates only 3.2% predictability.

Research Question 2

Research Question 2 examined the extent to which there is capacity outcome in the Griffin High School Integrative STEM Academy. Multiple data sets were examined in the study. Responses to capacity-related items of the survey in Appendix F were reported in Table 17. Capacity for the two subscales revealed mean scores for males of 4.29 for both knowledge and informational. The mean scores for female students were 4.50 on knowledge and 4.33 on informational. For all respondents, the results yielded *M* = 4.35, *SD* = .49 and *M* = 4.30, *SD* = .57 for dependent variables of knowledge and informational, respectively. The mean scores for socioeconomic status (determined by students on free/reduced lunch), and ethnicity/race subgroups are also similar with means mostly within the 4 to 5 range, indicating positive opinions. The multiple regression analyses indicated that independent variables cannot predict the dependent variable responses. The adjusted R^2 values are all low numbers for all models and suggested that the independent variables accounted for relatively small percentages of responses. For example, the adjusted value for the informational model was 0.115 or 11.5% predictability, and has an *F* value = 1.823, and *p* = .184, meaning there were no significant differences in the results.

Descriptive statistics of the archival school data for enrolled students' EOCT scores yielded a math mean score of 408.9 and a standard deviation of 15.3. This means that some of the student respondents failed the math EOCT, which requires a passing score of 400. Figure 4 showed that the passing rate was actually at 80%. For science, *M* = 475.6 and *SD* = 38.3., almost 2 standard deviations above the pass score. Figure 4 showed that 100% of the respondents passed their science EOCT and 65% exceeded the proficient mark of 450. In comparison, 80% passing in math is still a high-capacity level according to national and state passing rates.

For the socioeconomic status of enrolled students, the results were similar. The results for free/reduced lunch enrolled students (75%) were M = 409.5, SD = 15.9 in math and M = 475.1, SD = 39.5 in science. For enrolled students with High SES (25%), the results were M = 407.0, SD = 15.0 in math and M = 477.2, SD = 37.9 in science. The results for enrolled students (55%) of White ethnicity/race were M = 404.6, SD = 15.0 in math and M = 477.4, SD = 42.8 in science; for enrolled students (45%) of Black or African American ethnicity/race were M = 414.1, SD = 14.7 in math and M = 473.4, SD = 34.3 in science.

The results of the multiple regression analyses showed that there were no significant differences between the subgroups of the sample. For science scores, the adjusted R^2 = –.050, or 5% predictability, F value = .699, and p = .566. For math scores, the adjusted R^2 = –.027, or 2.7% predictability, F value =.833, and p = .495.

The results from multiple data sources indicated that capacity outcome experienced by respondents was at a high level. This was supported by the positive opinions of students and staff. The archival school data yielded EOCT scores that were at a high rate of passing when compared to statewide results. For example, 59% of students met or exceeded the standard for Mathematics II for Spring 2013, and 74% of students met or exceeded the standard for Biology (GADOE, 2011). In general, the national results are at a very low passing rate, and there are wide gaps among the subgroups. Figure 5 shows the national results for 12th graders' passing rates in math. The overall national math passing rate for 12th graders is only 26% (USDE, 2013).

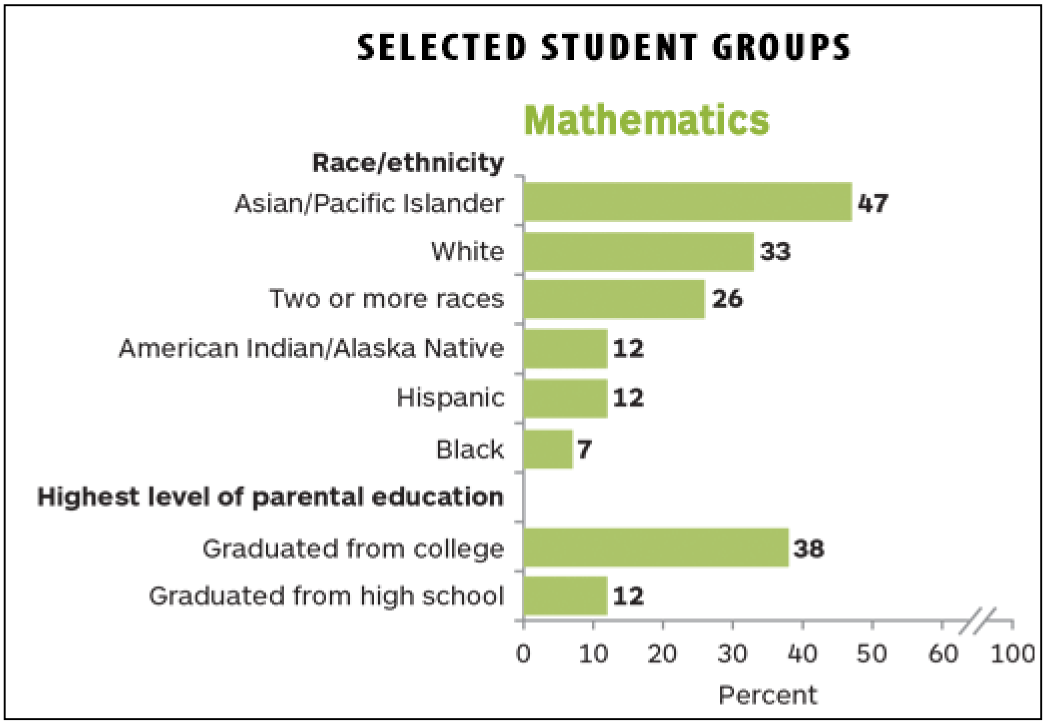

Figure 5. Selected student groups in Grade 12 that are at or above the *proficient* level in math. National average scores from the 2013 National Assessment of Educational Progress did not change from 2009 to 2013.

Research Question 3

Research Question 3 examined the extent to which there is continuity outcome in the Griffin High School Integrative STEM Academy. Multiple data sets were examined in the study. Data from responses to a survey based on a 3-point scale (i.e., *yes*, *no*, *I don't know*) contained positive statements about the support for STEM continuity (e.g., co-curricular/extracurricular activities, tutorial opportunities, SAT/ACT, etc.) and were analyzed for the student respondents. The results indicated that the enrolled students indicated high support for STEM continuity. For example, the male respondents had results of *M* = 5.80 and *SD* = 1.05 for *yes* responses, *M* = 1.60 and *SD* = .63 for *no* responses, and *M* = .60 and *SD* = .63 for *I don't know* responses. Similarly, the female respondents had results of *M* = 5.50 and *SD* = 1.05 for *yes* responses, *M* =

1.50 and *SD* = .55 for *no* responses, and *M* = 1.30 and *SD* = 1.34 for *I don't know* responses. The results varied slightly among subgroups but, based on the multiple regression analyses, confirmed that there were no significant differences in all models. One example is the influence model that has an adjusted R^2 = –.048, or 4.8% predictability, *F* value =.711, and *p* = .559.

Responses to continuity-related items in Student ECC Outcome Questionnaire (Appendix F) were reported in Tables 29 for subgroups based on gender. Continuity outcome was measured based on students' opinions on a 5-point scale for the three subscales influence, choice, and opportunity were relatively low. However, the results were more on the positive side of the scale. The results for all respondents were *M* = 2.75 and *SD* = 1.07 for influence, *M* = 3.58 and *SD* = 1.21 for choice, and *M* = 3.9 and *SD* = .55 for opportunities. The implication of these results is that there are factors other than the integrative STEM Academy that are acting on influence, choices, and opportunities toward STEM disciplines and STEM careers. Table 30 shows the descriptive statistics for subgroups based on socioeconomic status, and Table 31 shows the descriptive statistics for subgroups based on ethnicity/race. Multiple regression analyses showed consistency among the subgroups with no significant results. For example, the adjusted R^2 = –.167, or 16.7% predictability, *F* value = .092, and *p* = .963.

Research Question 4

Teacher questionnaires yielded results that reflected mostly positive opinions about continuity outcome. A 23-item teacher survey yielded responses at *M* = 4.71 and *SD* = 0.62. This means the staff expressed positive opinions or strong agreement that the Griffin High School Integrative STEM Academy is providing continuity support. The staff either *agreed* or *strongly agreed* that the Griffin High School Integrative STEM Academy is successful in facilitating

STEM learning. The second survey consisted of 7 items on a 5-point scale. The opinions expressed by respondents were neutral, as reflected in the results of M = 2.71 and SD = .76.

Research Question 5

The parent questionnaire yielded results that reflected positive opinions that the Griffin High School Integrative STEM Academy is providing STEM learning. The parent mostly agreed with positive statements about the Griffin High School Integrative STEM Academy. The results of M = 3.86 and SD = .86 suggested that parents have positive opinion about the integrative STEM Academy.

Research Question 6

Additional questionnaire data collected from administrator expressed positive continuity outcome support for the Griffin High School Integrative STEM Academy. Administrator expressed positive opinions as the results of M = 3.78, SD = .97 indicates. Nationally, there have been greater support from K-12 school administrators to find effective STEM Education programs, such as the Griffin High School Integrative STEM Academy program.

Conclusions

This program evaluation study examined the Griffin High School Integrative STEM Academy based on outcomes (i.e., engagement, capacity, and continuity) from the perspectives of enrolled student participants, their parents, staff, and administrators. The study also examined the enrolled students' archival school data. For each of the three outcomes, which were the dependent variables—engagement, capacity, and continuity—a majority of the respondents indicated positive opinions of the Griffin High School Integrative STEM Academy despite their gender, race/ethnicity, and socioeconomic status. There were no significant differences for any of the subgroups on any of the measures. It is therefore noteworthy that while there are gaps in the national outcomes in STEM disciplines, no significant gaps among the different subgroups were present in this study. Regarding the outcomes from the Griffin High School Integrative STEM Academy, there were no significant discrepancies with other highly successful STEM schools and programs across the United States (Jolly et al., 2004; NRC, 2011).

Both the student and staff respondents expressed opinions that indicated they either *agreed* or *strongly agreed* that the Griffin High School Integrative STEM Academy is providing engagement for STEM learning. Engagement is also being provided for all students as there were no significant differences in the responses among the various subgroups. Students are interested in STEM disciplines and STEM careers, as indicated from the STEM Semantics Survey. Tyler-Wood et al. (2010) conducted a study in which 60 middle school students participated in taking the STEM Semantics Survey that yielded positive perceptions of STEM disciplines and STEM careers. They obtained the following results: science M = 5.48, SD = 1.17; math M = 4.49, SD = 1.67; engineering M = 4.94, SD = 1.68; technology M = 5.69, SD = 1.33; and STEM careers M = 4.91, SD = 1.58. In the current study, the STEM Semantics Survey yielded the following results: science M = 5.19, SD = 1.29; math M = 4.59, SD = 2.02; engineering M = 5.80, SD = 1.04; technology M = 5.95, SD = 1.25; and STEM careers M = 5.17, SD = 1.32. The results are comparable despite the separation in time and grades. In addition, it is accepted that positive perceptions of science are lower among older students compared to younger students (UMass Donahue Institute, 2006), which means that there are no discrepancies in engagement interests of the Griffin High School Integrative STEM Academy. Archival school data also reflected a low level of discipline referrals, which supported the presence of behavioral engagement, which is consistent with a positive STEM learning environment. According to the UMass Donahue Institute (2006), students' negative behaviors affect STEM learning and must be targeted.

According to the staff of the Griffin High School Integrative STEM Academy, the few discipline referrals for enrolled students were more likely to occur outside while students are in other classes than within the Academy.

There was no indication of discrepancies in the capacity outcome between the Griffin High School Integrative STEM Academy and highly successful schools across the nation based on the data collected in this program evaluation study. Archival school data showed that enrolled students' EOCT scores in math and science indicated high-capacity outcome for all students. The mean EOCT scores of the Griffin High School Integrative STEM Academy were math M = 408.9 and SD = 15.3 and science M = 475.6 and SD = 38.3. They had a passing rate of 80% for math and 100% for science, which meets or exceeds proficiency. The school-wide mean scores of math M = 400.73 and science M = 411.49 for Spring 2013 indicated that the integrated STEM Academy students were successful. The Georgia statewide passing rates of approximately 59% for math and 74% for science indicate that the Griffin High School Integrative STEM Academy has a higher success rate. Nationally, standardized math and science test scores are at low levels (e.g., 26% proficiency in math for 12th graders) among the general population and wide gaps across various subgroups (i.e., gender, ethnicity/race, and socioeconomic status). Capacity outcome, based on the opinions of staff and students, is consistent with the archival school data in all respects and further showed no discrepancies with highly successful STEM schools and programs across the nation (Jolly et al., 2004; NRC, 2011).

The continuity outcome also showed that there were no discrepancies between the Griffin High School Integrative STEM Academy and highly successful schools across the nation based on the data collected in this program evaluation study. The data came from multiple sources of student, staff, administrator, and parent surveys. All respondents expressed positive opinions that there is continuity support for STEM learning. Consistent with continuity outcomes in highly successful STEM schools and programs, respondents expressed (i.e., *agree* or *strongly agree*) that students have access to tutorials, take the ACT/SAT, have access to extra-/co-curricular activities, and are aware of going to college (Jolly et al., 2004; NRC, 2011). The results overwhelmingly confirmed there are no discrepancies in the outcomes of this study with the characteristics of highly successful STEM schools and programs. This study also confirmed strong optimism for the implementation of integrative STEM programs. However, there are concerns that issues were observed during the study that were not addressed due to the limitations of the study. These concerns are consistent with what the literature has stated are some of the challenges of implementing and developing successful STEM programs:

- The staff and administrator confirmed the Griffin High School Integrative STEM Academy has only fully functioned for the 2012–2013 school year, but became dysfunctional in 2013–2014. The retirement of the engineering and technology teacher affected the staffing.
- The school system needs to provide adequate professional development for staff. The newly hired engineering and technology teacher was not prepared enough to get on board with the integrative STEM Academy program.
- The school system needs to develop appropriate scheduling to facilitate integrative STEM within the traditional school program. Also, the rest of the Griffin High School staff were not in agreement that three teachers should share only 60 students while everyone else carried a full load.

Implications

Perhaps one of the most important findings of this study is that the data overwhelmingly suggested that the Griffin High School Integrative STEM Academy is a highly successful STEM program that is consistent with criteria for successful STEM schools and programs across the United States. Respondents expressed mostly positive views of the integrative STEM Academy, which indicated a high level of engagement, capacity, and continuity outcomes (Jolly et al., 2004). In addition, the school data reflected a high degree of success in math (80% passing) and science (100% passing, 65% of them exceeding proficiency). The results of the study suggested the integrative STEM academy yielded successes that are similar to what has been cited in the literature (NRC, 2011) about some of the United States' most successful STEM schools and programs.

The results of the study indicated that the Griffin High School Integrative STEM Academy is an example of what it means to be meeting the U.S. STEM goals (NRC, 2011; President's Council, 2010). The U.S. STEM goals are designed to (a) increase the number of students who will go on to pursue careers in STEM fields, (b) broaden the participation of women and minority groups to expand the STEM work force, and (c) increase literacy in STEM disciplines for all students who may or may not pursue STEM careers (NRC, 2011). In order for the United States to meet these goals, school systems need to improve on and increase programs such as the Griffin High School Integrative STEM Academy despite the barriers that exist (Becker & Park, 2011). Doing so is necessary to increase advanced training and careers in STEM fields, to expand the STEM-capable work force, and to increase scientific literacy among the general public—all of which are central to STEM practices and learning (Hanover Research, 2011).

One outstanding factor this study highlighted about the Griffin High School Integrative Academy is that there are no outcome disparities for STEM disciplines. The multiple regression analysis of mean scores for subgroups determined by gender, ethnicity/race, and socioeconomic status showed no significant differences. It is a significant success for the Griffin High School Integrative STEM Academy to have relatively high representation within subgroups and a high level of success within multiple subgroups. This is an anomaly compared to the wide gaps in student outcomes that are generally the case nationally. For example, studies by the National Assessment of Educational Progress have shown a trend that has not changed from 2009 through 2013 in math: Blacks meeting or exceeding proficiency in math in Grade 12 at a low 7%, compared to 47% for Whites (USDE, 2013). That is why there is a goal to increase women and minorities in STEM disciplines. This is why this study was important not just for the Griffin High School Integrative STEM Academy to identify areas in which improvements can be made, but also to be an example for other schools.

Finally, integrative STEM programs that connect the disciplines through the use of blended curricula and team teaching are rare. According to M. Sanders and Wells (2006), integrative STEM is a learning approach that intentionally integrates the concepts and practices of science and/or mathematics education with the concepts and practices of technology and engineering education. It is a reflection of a high level of support from school administrators at all levels. The administrators, from the building principal to the Griffin-Spalding School System superintendent, deserve much praise for that level of support. The staff also must be congratulated for the effort they took to enter that level of partnership within the school system. They risked what could have been a great disappointment had the students not performed successfully. M. Sanders (2012) stated that integrative STEM education does not guarantee best practices in STEM programs and should rather be guided by standards and rely more on the evidence that can be obtained through evaluation or research processes. Thus, this study may be useful in helping to encourage the Griffin High School Integrative STEM Academy to build and broaden its program to reach more students within the school community. This study can also be used to help other school systems that might be looking for ways to increase STEM learning.

Recommendations

The following recommendations for practice and further research are made based on the findings and conclusions of this study.

1. School district leaders may want to further analyze the results of this study as they consider integrative STEM as a viable option for increasing STEM learning for all students. It is favored by the individuals it serves—participating students. Therefore, it is worthy of deeper consideration and additional support to improve overall quality of program.
2. It is recommended that students and parents should be further informed in a special way that their local integrative STEM academy as a viable high school alternative STEM program that is highly beneficial. The positive outcomes (i.e., EOCT scores and students' opinions) revealed in this study suggested that the Griffin High School Integrative STEM Academy yielded success with participating students that is worth repeating. These results illustrate that this integrative STEM model has the potential to make an impact on all of the Griffin High School students to significantly increase math and science EOCT scores.
3. Integrative STEM education programs similar to the one examined in this study are likely able to improve students' discipline and help them stay focus on STEM career

pathways for students beyond high school—essential elements that are necessary for success in the global economy (Carnevale et al., 2011; National Governors Association, 2007).

4. Follow-up research is necessary to monitor the continued implementation and development of the STEM Academy. Future longitudinal research should be conducted to measure outcomes of from the integrative STEM academy at different stages of the implementation process, and address whether enrolled students will actually go on to gain successful STEM careers.
5. The results of this study suggest that the Griffin High School Integrative STEM Academy model should be considered by local government and school leaders as a potential solution for meeting STEM goals. As a STEM program with a high degree of successful outcomes for all subgroups, with no significant differences in student success, this integrative STEM Academy needs to be considered further as model program that is worth replicating to help bridging the wide gaps in STEM achievements.
6. Increase resources in curriculum development, STEM supplies to improve the quality of the integrative STEM academy offerings. While this study of the Griffin High School Integrative STEM Academy indicated a high level of success, additional curriculum resources and investments are necessary for improvements in order to optimize its instructional practices and to help increase the number of participating students.

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APPENDIX A

APPROVAL FORMS

IRB Approval Letter

The University of Georgia

Phone 706-542-3199Fax 706-542-3660
Office of the Vice President for Research
Institutional Review Board

APPROVAL OF PROTOCOL

May 12, 2014
Dear Robert Wicklein:
On 5/12/2014, the IRB reviewed the following submission:

Type of Review:	Initial Study
Title of Study:	A Formative Evaluation of Griffin High School Integrative Science, Technology, Engineering, and Mathematics (STEM) Academy
Investigator:	Robert Wicklein
IRB ID:	STUDY00000557
Funding:	None
Grant ID:	None

The IRB approved the protocol from 5/12/2014 to 5/11/2015 inclusive. Before 5/11/2015 or within 30 days of study closure, whichever is earlier, you are to submit a continuing review with required explanations. You can submit a continuing review by navigating to the active study and clicking Create Modification / CR.
If continuing review approval is not granted before the expiration date of 5/11/2015, approval of this study expires on that date.
To document consent, use the consent documents that were approved and stamped by the IRB. Go to the Documents tab to download them.
In conducting this study, you are required to follow the requirements listed in the Investigator Manual (HRP-103).
Sincerely,
Larry Nackerud, Ph.D.
University of Georgia
Institutional Review Board Chairperson

629 Boyd Graduate Studies Research Center ◆Athens, Georgia 30602-7411
An Equal Opportunity/Affirmative Action Institution
629 Boyd Graduate Studies Research Center ◆ Athens, Georgia 30602-7411
An Equal Opportunity/Affirmative Action Institution

Griffin-Spalding County School District Approval Letter

Griffin-Spalding County Schools

Human Subjects Review – System Approval Form

Employee's Name: Ezra Thompson

School: University of Georgia

Address: 850 College Station Road, 223 River's Crossing Building, Athens, GA 30602

Title of Research Project: A Formative Evaluation of Griffin High School Integrative STEM Academy

Program and Degree of Study: Workforce Education, Doctor of Education Degree

Project Proposed Start Date: January 1, 2013 Project Proposed Completion Date: May 30, 2014

Approval Signatures: D RB

DO NOT PROCEE TO COLLECT DATA PRIOR TO RECEIVING I APPROVAL

Circle the following either "Yes" or "No":

a. Research involving minors or students: Circle **N** if the research only involved the observation of public behavior by the investigator. **Y** **N**

b. Research involving intellectually, mentally, or physically challenged members of protected groups. **Y** **N**

c. Research involving subject deception of any kind. **Y** **N**

Please complete:

1. Study Site and Participants: This study will be conducted at the Griffin High School of the Griffin-Spalding County School System in Georgia, and include students enrolled in the Griffin High School Integrative STEM Academy. Other participants will include teachers, administrators, and parents of the enrolled students.

2. Brief but detailed summary of the Project (attach extra page if needed).
   The objective of this study is to conduct a formative program evaluation in order to identify areas in an integrative science, technology, engineering, and mathematics (STEM) education program that need improvement. The formative evaluation will be done using a discrepancy model approach to identify differences between successful national STEM programs and the Griffin High School Integrative STEM Academy. Successful K-12 STEM education programs (National Research Council, 2011) should be based on three criteria that are that are related to outcomes of engagement, capacity, and continuity or the ECC trilogy (Jolly et al., 2004). These criteria (See attachment – Research Overview, for more details) will also guide the type of outcome data collected in order to answer the main questions of study.

3. Describe the nature of the involvement of human subjects in the project (personal interview, mailed questionnaire, observation, etc. (Attach copy of any instrument, chart, or questionnaire that will be used with subjects.) Human subjects (e.g. students, teachers, administrators, and parents) involved in this research will be asked to questionnaires. Student achievement data from school archival documentation (e.g. end of course test scores) will also be requested (Please see attachment- Instrument for more details). Questionnaires will be done electronically on computers through a secured web link.

4. Describe how confidentiality will be maintained. Be specific if using secondary documents, audio/video tapes, etc.
   The data will be anonymous by not collecting individual identifiable information. No collection of audio/video or any identifiable information (e.g. name, SSN, address, phone, email, or medical information) is necessary in this study.

5. Signature and date of review:

   Student/Date ______________________ 12/14/2014

   Dissertation Committee Chair/Co-Chair/ Date ______________________ 12/11/2014

   Superintendent/Date ______________________ 12-27-14

Attach any other forms, tests, institutional permission slips, etc., relative to this study. Failure to do so will result in delayed processing of the approval form.

APPENDIX B

CONSENT FORMS

Parental Permission Form

Approved by University of Georgia
Institutional Review Board
Protocol # STUDY00000557
Approved on: 5/12/2014
For use through: 5/11/2015

UNIVERSITY OF GEORGIA
PARENTAL PERMISSION FORM
A Formative Evaluation of Griffin High School Integrative Science, Technology, Engineering, and Mathematics (STEM) Academy.

Researcher's Statement

I am asking for you to allow your child to take part in a research study. Before you decide to let your son or daughter participate in this study, it is important that you understand why the research is being done and what it will involve. This form is designed to give you the information about the study so you can decide whether to be in the study or not. Please take the time to read the following information carefully. Please ask the researcher if there is anything that is not clear or if you need more information. When all your questions have been answered, you can decide if you want your child to be in the study or not. This process is called "informed consent." A copy of this form will be given to you.

Principal Investigator: Dr. Robert Wicklein

Department of Career and Information Studies

Tel.: 706.542. 4503 or by e-mail to wickone@uga.edu

Purpose of the Study

The goal of Griffin High School Integrative STEM Academy is to provide students with the highest level of success in science, technology, engineering, and mathematics (STEM). We live in a society with an economy that is highly STEM based. It demands effective training programs that will prepare students with high levels of STEM skills in order for them to benefit from the occupations that are being created in the 21st century (National Research Council, 2011).
The purpose of this study is to conduct a Program Evaluation Research in order to identify and improve areas of the Griffin High School Integrative STEM Academy that needs improvement.

Study Procedures

If you allow your child to participate:

1. He/she will be asked to complete a questionnaire based on her/his knowledge of the Griffin High School Integrative STEM Academy and should only take about 15 to 25 minutes. Questionnaire access cards will be made available for your child to randomly pick a card with user code and web link information if he/she chooses to participate in this research.
2. The researcher will use your child's coded information/data (i.e. end of course test scores in math and science, and attendance records) that were collected during his/her involvement with the Griffin High School Integrative Academy during the period from August 2012 to December 2013. If you do not agree to allow your child to participate, your child will not take the STEM questionnaire and the researchers will not obtain any information from your child's school records.

Risks and discomforts

 I do not anticipate any risks from participating in this research.

Benefits

- There are no direct benefits for participant in this study.

- The expected benefits will be to gain understanding of ways in which to improve the Griffin High School Integrative STEM Academy. This knowledge is expected to indirectly help students to be more prepared function in the STEM based workforce of the 21st century.

Incentives

- Participant will not receive any incentive (monetary or non-monetary) for being in the study.

Privacy/Confidentiality

- There is a limit to the confidentiality that can be guaranteed in this study due to the internet technology itself. However, the researcher will ensure that the confidentiality of participant will be guaranteed by utilizing standard procedures, when the researcher writes up the final research product. The identifiers (names, addresses, phones, and emails) of participant are not required for the outcome of this study and will not be used on online surveys. Researchers will not release identifiable results of the study to anyone other than individuals working on the project without your written permission unless required by law. The project's research records may be reviewed by the Institutional Review Board (IRB) at the University of Georgia responsible for regulatory and research oversight.
- All information that can be used to identify your child will be coded and removed from the research record immediately after data collection has been completed.
- There is a limit to the confidentiality that can be guaranteed due to the internet technology itself. However, the researcher will ensure that the confidentiality of participant will be guaranteed by utilizing standard procedures, when the researcher writes up the final research product. The researcher cannot ensure confidentiality during the actual Internet communication procedure. Therefore, a user code will be randomly chosen by participants to complete survey over the internet without the use of any personal information.

- The researcher: Ezra Thompson will answer any questions about the research now, or during the course of the project, and can be reached by telephone at 678.634.9317 or email at ezth08@uga.edu. I may also contact the professor supervising the research, Dr. Wicklein Faculty Advisor, at (706) 542-4503 or wickone@uga.edu. If you have any questions or concerns regarding your rights as a research participant in this study, you may contact the Institutional Review Board (IRB) Chairperson at 706.542.3199 or irb@uga.edu.

Taking part is voluntary

Your child's involvement in the study (i.e. program evaluation and research) is voluntary, and may choose not to participate or to stop at any time without penalty or loss of benefits to which you are otherwise entitled. If your child decides to stop or withdraw from the study, the information/data collected from or about you he/she up to the point of withdrawal will be kept as part of the study and may continue to be analyzed. Your decision whether or not to allow your child to participate in the research will not impact your child's grades or class standing.

Subject's Consent to Participate in Research:

To voluntarily allow your child to take part in this study, you must sign on the line below. Your signature below indicates that you have read or had read to you this entire Parental Permission Form, and have had all of your questions answered.

Your Child's Name: ______________________________________

Parent/Guardian Signature: ____ Date ____________

Parent/Guardian
Printed Name: ____

______________________________________ Date ______________

Signature of
Researcher: Ezra Thompson

Printed Name of Researcher:

Please sign both copies, keep one and return one to the researcher.

Student Assent Form

Approved by University of Georgia
Institutional Review Board
Protocol # STUDY00000557
Approved on: 5/12/2014
For use through: 5/11/2015

Assent Form for Participation in Research A Formative Evaluation of Griffin High School Integrative Science, Technology, Engineering, and Mathematics (STEM) Academy.

We are conducting a research study to find out how to improve the Griffin High School Integrative science, Technology, Engineering, and Mathematics, (STEM) Academy. We are asking you to be in the study because you are in the STEM Academy. If you agree to be in the study, you will be asked to complete a self report survey that will take about 20 -25 minutes. The survey is designed to gather information that reflects your experience in Griffin High School Integrative STEM Academy. For example, you will be asked if STEM activities gained your interest or if the integrative STEM academy provides opportunities for you to pursue career in STEM fields. The researcher will also use your coded information/data (i.e. end of course test scores in math and science, and attendance records). The expected benefits will be to understand ways in which to improve the Integrative STEM Academy. This study may help students to be more prepared careers that are being created in the STEM based workforce of the 21st century. There are no risks involved if you participate.

You do not have to say “yes” if you don’t want to. No one, including your parents, will be mad at you if you say “no” now or if you change your mind later. We have also asked your parent’s permission to do this. Even if your parent says “yes,” you can still say “no.” Remember, you can ask us to stop at any time. Your grades in school will not be affected whether you say “yes” or “no.”

If the information from this study is able to help improve the Griffin High School Integrative STEM Academy it may become a model that may become examples for other schools like Griffin High School who are seeking to develop their STEM programs. We will not use your name on any papers that we write about in this project. We will only use the resulting scores, so other people cannot tell who you are.

You can ask any questions that you have about this study. If you have a question later that you didn’t think of now, you can contact Ezra Thompson who will answer any questions about the research now, or during the course of the project, and can be reached by telephone at (678) 634-9317 or email at ezth08@uga.edu. You may also contact the professor supervising the research, Dr. Wicklein Faculty Advisor, at (706) 542-4503 or wickone@uga.edu. If you have any questions or concerns regarding your rights as a research participant in this study, you may contact the Institutional Review Board (IRB) Chairperson at (706) 542-3199 or irb@uga.edu.

Name of Child: ______________________________ **Parental Permission on File:** ☐ Yes ☐ No

Signing here means that you have read this paper or had it read to you and that you are willing to be in this study. If you don’t want to be in the study, don’t sign.

Signature of Child: ________________________________ **Date:** __________________

Signature of Researcher: **Date:** __________________

____

Student Consent Form

Approved by University of Georgia
Institutional Review Board
Protocol # STUDY00000557
Approved on: 5/12/2014
For use through: 5/11/2015

UNIVERSITY OF GEORGIA
CONSENT FORM
A Formative Evaluation of Griffin High School Integrative Science, Technology, Engineering, and Mathematics (STEM) Academy.

Researcher's Statement

I am asking you to take part in a research study. Before you decide to participate in this study, it is important that you understand why the research is being done and what it will involve. This form is designed to give you the information about the study so you can decide whether to be in the study or not. Please take the time to read the following information carefully. Please ask the researcher if there is anything that is not clear or if you need more information. When all your questions have been answered, you can decide if you want to be in the study or not. This process is called "informed consent." A copy of this form will be given to you.

Principal Investigator: Dr. Robert Wicklein

Department of Career and Information Studies
Tel.: 706.542. 4503 or by e-mail to wickone@uga.edu

Purpose of the Study

The goal of Griffin High School Integrative STEM Academy is to provide students with the highest level of success in science, technology, engineering, and mathematics (STEM). We live in a society with an economy that is highly STEM based. It demands effective training programs that will prepare students with high levels of STEM skills in order for them to benefit from the occupations that are being created in the 21st century (National Research Council, 2011). The purpose of this study is to conduct a Research Evaluation and Assessment of the Griffin High School Science,
Technology, Engineering, and Mathematics (STEM) Academy in order to identify areas that can improve teaching and learning.

Study Procedures

If you agree to participate, you will be asked to …

- Complete a self-report survey that will take about 20-25 minutes to reflect your experience in Griffin High School Integrative STEM program. This activity will take place once during a specified time in school computer lab that will be agreed on by the school administration
- Allow the researchers to use your coded information/data (i.e. end of course test scores in math and science, and attendance records) that were collected during your involvement with the Griffin High School Integrative Academy. If you do not participate, you will not take the STEM questionnaire and the researchers will not obtain any information from your school records.

Risks and discomforts

- We do not anticipate any risks from participating in this research.

Benefits

- There are no direct benefits for participant in this study.
- The expected benefits will be to gain understanding of ways in which to improve the Griffin High School Integrative STEM Academy. This knowledge is expected to indirectly help students to be more prepared function in the STEM based workforce of the 21st century. **Incentives for participation**

Approved by University of Georgia
Institutional Review Board
Protocol # STUDY00000557
Approved on: 5/12/2014
For use through: 5/11/2015

- Participant will not receive any incentive (monetary or non-monetary) for being in the study.

Privacy/Confidentiality

- There is a limit to the confidentiality that can be guaranteed in this study due to the internet technology itself. However, the researcher will ensure that your confidentiality will be protected by utilizing standard procedures, when the researcher writes up the final research product. Researchers will not release identifiable results of the study to anyone other than individuals working on the project without your written permission unless required by law. The project's research records may be reviewed by the Institutional Review Board (IRB) at the University of Georgia responsible for regulatory and research oversight.
- All information that can be used to identify you will be coded and the code key will be destroyed immediately after data collection has been completed.
- The researcher cannot ensure confidentiality during the actual Internet communication procedure. Therefore, a user code will be randomly chosen by you to access survey over the internet without the use of any personal information.
- The researcher: Ezra Thompson will answer any questions about the research now, or during the course of the project, and can be reached by telephone at 678.634.9317 or email at ezth08@uga.edu. I may also contact the professor supervising the research, Dr. Wicklein Faculty Advisor, at (706) 542-4503 or wickone@uga.edu. If you have any questions or concerns regarding your rights as a research participant in this study, you may contact the Institutional Review Board (IRB) Chairperson at 706.542.3199 or irb@uga.edu.

Taking part is voluntary

Your involvement in the study is voluntary, and you may choose not to participate or to stop at any time without penalty or loss of benefits to which you are otherwise entitled. If you decide to stop or withdraw from the study, the information/data collected from or about you up to the point of your withdrawal will be kept as part of the study and may continue to be analyzed. Your decision whether or not to participate will not impact your grades or class standing.

Research Subject's Consent to Participate in Research:
To voluntarily agree to take part in this study, you must sign on the line below. Your signature below indicates that you have read or had read to you this entire consent form, and have had all of your questions answered.

_________________________	_______________________	_________
Name of Researcher	Signature	Date
________________________	_______________________	__________
Name of Participant	Signature	Date

Please sign both copies, keep one and return one to the researcher.

Teacher Consent Letter

Approved by University of Georgia
Institutional Review Board
Protocol # STUDY00000557
Approved on: 5/12/2014
For use through: 5/11/2015

Consent Letter

Dear Staff:

I am a graduate student under the direction of Professor Robert Wicklein in the Department of Career and Information Studies at The University of Georgia. I invite you to participate in a program evaluation/research study entitled "A Formative Evaluation of Griffin High School Integrative Science, Technology, Engineering, and Mathematics (STEM) Academy" that is being conducted. The purpose of this study is to conduct a formative program evaluation of the Spalding County – Griffin High School integrative STEM Academy in order to identify areas that can be change to improve STEM teaching and learning opportunities.

Your participation will involve completing an online questionnaire based on your knowledge of the Griffin High School Integrative STEM Academy and should only take about 10 to 15 minutes. Your involvement in the study is voluntary, and you may choose not to participate or to stop at any time without penalty or loss of benefits to which you are otherwise entitled. Your decision whether to participate in the research or not will not impact your employment. If you decide to withdraw from the study, the information that can be identified as yours will be kept as part of the study and may continue to be analyzed, unless you make a request to remove, return, or destroy the information.

The confidentiality of participants in this study cannot be fully guaranteed due to the internet technology itself. The researcher cannot ensure confidentiality during the actual Internet communication procedure. Therefore, a user code only will be used for participants to access the online survey without the use of any personal information. The code will also be randomly selected. The researcher will ensure that the confidentiality of participant will be protected by utilizing standard procedures, when the researcher writes up the final research product.

The results of the research study may be published, but your name or any identifying information will be coded and removed immediately after data is collected. In fact, the published results will be presented in summary form only.

The findings from this project may provide information on changes that are necessary for the development of a successful Integrative STEM Academy. This may help to improve STEM teaching and learning for the benefit of Griffin High School students. There are no known risks or discomforts associated with this research.

If you have any questions about this research project, please feel free to call me at 678.634.9317 or email at ezth08@uga.edu. You may also contact the professors supervising the research, Dr. Robert Wicklein, Faculty Advisor, at 706.542. 4503 or by e-mail to wickone@uga.edu. Questions or concerns about your rights as a research participant should be directed to The Chairperson, University of Georgia Institutional Review Board, 629 Boyd GSRC, Athens, Georgia 30602; telephone (706) 542-3199; email address irb@uga.edu.

You may go online with your web link information to access survey. By completing and pressing "submit" you will be agreeing to participate in the above described research project. Web link to survey is as follows: https://www.surveymonkey.com/s/7CMK9VB. Then enter the following user code: _________________ to access survey.

Approved by University of Georgia
Institutional Review Board
Protocol # STUDY00000557
Approved on: 5/12/2014
For use through: 5/11/2015

Thank you for your consideration! Please keep this letter for your records.

Sincerely,

Ezra Thompson

Parent Consent Letter

Approved by University of Georgia
Institutional Review Board
Protocol # STUDY00000557
Approved on: 5/12/2014
For use through: 5/11/2015

Consent Letter

Dear Parent/Guardian:
I am a graduate student under the direction of Professor Robert Wicklein in the Department of Career and Information Studies at The University of Georgia. I invite you to participate in a research study entitled "A Formative Evaluation of Griffin High School Integrative Science, Technology, Engineering, and Mathematics (STEM) Academy" that is being conducted. The purpose of this study is to conduct a formative program evaluation of the Spalding County – Griffin High School integrative STEM Academy in order to identify areas that can improve teaching and learning.
Your participation will involve completing an online questionnaire based on your knowledge of the Griffin High School Integrative STEM Academy and should only take about 5 to 10 minutes.
Your involvement in the study is voluntary, and you may choose not to participate or to stop at any time without penalty or loss of benefits to which you are otherwise entitled. If you decide to withdraw from the study, the information that can be identified as yours will be kept as part of the study and may continue to be analyzed, unless you make a request to remove, return, or destroy the information.
The confidentiality of participants in this study cannot be fully guaranteed due to the internet technology itself. The researcher cannot ensure confidentiality during the actual Internet communication procedure.
Therefore, a user code only will be used for participants to access the online survey without the use of any personal information. The code will also be randomly selected. The researcher will ensure that the confidentiality of participant will be protected by utilizing standard procedures, when the researcher writes up the final research product.
The results of the research study may be published, but your name or any identifying information will be coded and removed immediately after data is collected. In fact, the published results will be presented in summary form only.
The findings from this project may provide information on changes that are necessary for the development of a successful Integrative STEM Academy. This may help to improve STEM teaching and learning for the benefit of Griffin High School students. There are no known risks or discomforts associated with this research.
If you have any questions about this research project, please feel free to call me at 678.634.9317 or email at ezth08@uga.edu. You may also contact the professors supervising the research, Dr. Robert Wicklein, Faculty Advisor, at 706.542. 4503 or by e-mail to wickone@uga.edu.
Questions or concerns about your rights as a research participant should be directed to The Chairperson, University of Georgia Institutional Review Board, 629 Boyd GSRC, Athens, Georgia 30602; telephone (706) 542-3199; email address irb@uga.edu.
You may go online with your web link information to access survey. By completing and pressing "submit" you will be agreeing to participate in the above described research project. Web link survey is as follows: https://www.surveymonkey.com/s/7Y7WCTX. Then enter the following user code: __________________ to access survey.

Approved by University of Georgia
Institutional Review Board
Protocol # STUDY00000557
Approved on: 5/12/2014
For use through: 5/11/2015

Thank you for your consideration! Please keep this letter for your records.

Sincerely,

Ezra Thompson

Administrator Consent Letter

Approved by University of Georgia
Institutional Review Board
Protocol # STUDY00000557
Approved on: 5/12/2014
For use through: 5/11/2015

Consent Letter

Dear Administrator:

I am a graduate student under the direction of Professor Robert Wicklein in the Department of Career and Information Studies at The University of Georgia. I invite you to participate in a research study entitled "A Formative Evaluation of Griffin High School Integrative Science, Technology, Engineering, and Mathematics (STEM) Academy" that is being conducted. The purpose of this study is to conduct a formative program evaluation of the Spalding County – Griffin High School integrative STEM Academy in order to identify areas that can improve teaching and learning.

Your participation will involve completing an online questionnaire based on your knowledge of the Griffin High School Integrative STEM Academy and should only take about 10 to 15 minutes. Your involvement in the study is voluntary, and you may choose not to participate or to stop at any time without penalty or loss of benefits to which you are otherwise entitled. Your decision whether to participate in the research or not will not impact your employment. If you decide to withdraw from the study, the information that can be identified as yours will be kept as part of the study and may continue to be analyzed, unless you make a request to remove, return, or destroy the information.

The confidentiality of participants in this study cannot be fully guaranteed due to the internet technology itself. The researcher cannot ensure confidentiality during the actual Internet communication procedure.

Therefore, a user code only will be used for participants to access the online survey without the use of any personal information. The code will also be randomly selected. The researcher will ensure that the confidentiality of participant will be protected by utilizing standard procedures, when the researcher writes up the final research product.

The results of the research study may be published, but your name or any identifying information will be coded and removed immediately after data is collected. In fact, the published results will be presented in summary form only.

The findings from this project may provide information on changes that are necessary for the development of a successful Integrative STEM Academy. This may help to improve STEM teaching and learning for the benefit of Griffin High School students. There are no known risks or discomforts associated with this research.

If you have any questions about this research project, please feel free to call me at 678.634.9317 or email at ezth08@uga.edu. You may also contact the professors supervising the research, Dr. Robert Wicklein, Faculty Advisor, at 706.542. 4503 or by e-mail to wickone@uga.edu.

Questions or concerns about your rights as a research participant should be directed to The Chairperson, University of Georgia Institutional Review Board, 629 Boyd GSRC, Athens, Georgia 30602; telephone (706) 542-3199; email address irb@uga.edu.

You may go online with your web link information to access survey. By completing and pressing "submit" you will be agreeing to participate in the above described research project. Web link to survey is as follows: https://www.surveymonkey.com/s/7JLPVJC. Then enter the following user code: _________________ to access survey.

Approved by University of Georgia
Institutional Review Board
Protocol # STUDY00000557
Approved on: 5/12/2014
For use through: 5/11/2015

Thank you for your consideration! Please keep this letter for your records. Sincerely,

Ezra Thompson

APPENDIX C

STEM SEMANTICS SURVEY

STEM Semantics Survey

Gender: M / F

This five-part questionnaire is designed to assess your perceptions of scientific disciplines. It should require about 5 minutes of your time. Usually it is best to respond with your first impression, without giving a question much thought. Your answers will remain confidential.

ID: ________________ **School:**_____________	Use the assigned ID or the year and day of your birthday (ex: 9925 if born on the 25th day of any month in 1999.

Instructions: Choose one circle between each adjective pair to indicate how you feel about the object.

To me, SCIENCE is:

1.	fascinating	①	②	③	④	⑤	⑥	⑦	mundane
2.	appealing	①	②	③	④	⑤	⑥	⑦	unappealing
3.	exciting	①	②	③	④	⑤	⑥	⑦	unexciting
4.	means nothing	①	②	③	④	⑤	⑥	⑦	means a lot
5.	boring	①	②	③	④	⑤	⑥	⑦	interesting

To me, MATH is:

1.	boring	①	②	③	④	⑤	⑥	⑦	interesting
2.	appealing	①	②	③	④	⑤	⑥	⑦	unappealing
3.	fascinating	①	②	③	④	⑤	⑥	⑦	mundane
4.	exciting	①	②	③	④	⑤	⑥	⑦	unexciting
5.	means nothing	①	②	③	④	⑤	⑥	⑦	means a lot

To me, ENGINEERING is:

1.	appealing	①	②	③	④	⑤	⑥	⑦	unappealing
2.	fascinating	①	②	③	④	⑤	⑥	⑦	mundane
3.	means nothing	①	②	③	④	⑤	⑥	⑦	means a lot
4.	exciting	①	②	③	④	⑤	⑥	⑦	unexciting
5.	boring	①	②	③	④	⑤	⑥	⑦	interesting

To me, TECHNOLOGY is:

1.	appealing	①	②	③	④	⑤	⑥	⑦	unappealing
2.	means nothing	①	②	③	④	⑤	⑥	⑦	means a lot
3.	boring	①	②	③	④	⑤	⑥	⑦	interesting
4.	exciting	①	②	③	④	⑤	⑥	⑦	unexciting
5.	fascinating	①	②	③	④	⑤	⑥	⑦	mundane

To me, a CAREER in science, technology, engineering, or mathematics (is):

1.	means nothing	①	②	③	④	⑤	⑥	⑦	means a lot
2.	boring	①	②	③	④	⑤	⑥	⑦	interesting
3.	exciting	①	②	③	④	⑤	⑥	⑦	unexciting
4.	fascinating	①	②	③	④	⑤	⑥	⑦	mundane
5.	appealing	①	②	③	④	⑤	⑥	⑦	unappealing

Note. Adapted from Instruments for assessing interest in STEM content and careers. *Journal of Technology and Teacher Education, 18*(2), 341–363, 2010. Copyright 2010 by Tyler-Wood, Knezek & Christensen.

APPENDIX D

CONTINUITY OUTCOME SURVEYS

Student Continuity Survey

		Yes	No	Don't Know
1	Are there opportunities to participate in co-curricular/extracurricular STEM-related activities?			
2	Are STEM-related tutorials available to you outside of regular class?			
3	Are there any reasons why you will not take the SAT/ACT? Why?			
4	Are you aware of any STEM-related summer camps that may be of interest to you?			
5	Are there any STEM professionals/counselors that you can go to for career advice?			
6	Are there more advance engineering courses you can take in school?			
7	Do you know of colleges you can go to further you education in STEM-related fields?			
8	Do you know any business or industry that requires STEM skills in the career area that is of interest to you?			

Note. Adapted from *Engagement, Capacity, and Continuity: A Trilogy for Student Success*, by E. J. Jolly, P. B. Campbell, and L. Perlman, 2004, Groton, MN: Campbell-Kibler Associates. Copyright 2004 by Campbell-Kibler Associates.

Teacher Continuity Survey

SD = Strongly Disagree, D = Disagree, N = Neutral, A = Agree, SA = Strongly Agree

	SD	D	N	A	SA
I feel positive about my role as a staff member within the STEM Academy.					
I work with people who collaborate with each other to make student learning consistent with the national STEM goals.					
I work with people who are committed to developing a quality integrative STEM program.					
My administrators support the staff of the STEM Academy in their work with students.					
My administrators are effective in helping us reach our vision.					
I believe student achievement can increase through the integrative STEM curriculum activities.					
I believe student achievement can increase through the integrative STEM instructional practices.					
I love working with the integrative STEM Academy.					
I believe STEM learning is for every student.					
I believe the Integrative STEM Academy provides an atmosphere where every student can succeed.					
I believe quality work is expected of all staff involved in this academy.					
I believe the vision for this academy is clear and shared.					
I believe this school has an action plan in place which will get us to accomplish our vision.					
I believe this academy has a good school and community image.					
I believe it is important to communicate often with parents.					
I believe student outcomes for the integrative STEM Academy are clear to me.					
I believe student outcomes for the integrative STEM Academy are clear the students.					
I work effectively with ethnically/racially diverse students.					
I work effectively with gender diverse students.					
I work effectively with socioeconomically diverse students.					
I work effectively with cognitively diverse students.					
Morale is high on the part of student’s involvement in STEM Academy.					
Morale is high on the part of teacher’s involvement in STEM Academy.					
Morale is high on the part of school administrator’s involvement in STEM Academy.					
Morale is high on the part of parents/community involvement in STEM Academy.					

Note. Adapted from Data analysis: For continuous school improvement. New York, NY, 2004. Copyright 2004 by Bernhardt, V. L.

Parent Continuity Survey

SD = Strongly Disagree, D = Disagree, N = Neutral, A = Agree, SA = Strongly Agree

	SD	D	N	A	SA
Parents are adequately aware of the Griffin High School Integrative STEM Academy.					
My child receive adequate orientation to the school's integrative STEM Academy.					
The STEM Academy provides adequate information about attending college to pursue STEM degrees after graduation.					
The STEM Academy provides adequate information about non-college STEM career options after graduation.					
The STEM Academy provides an adequate calendar of STEM activities.					
The STEM Academy provides adequate information about how parent volunteers can help.					
Parent volunteers feel appreciated and are vital to the integrative STEM Academy.					
All students are treated fairly by teachers in the integrative STEM Academy.					
I believe the integrative STEM Academy will meet the academic needs of the students.					
I believe STEM learning is for every student.					
I believe the Integrative STEM Academy provides an atmosphere where every student can succeed.					
I believe the integrative STEM Academy is succeeding at preparing students for college.					
I believe the integrative STEM Academy is succeeding at preparing students for future jobs.					
I would recommend this integrative STEM Academy to other families.					

Note. Adapted from Data analysis: For continuous school improvement. New York, NY, 2004. Copyright 2004 by Bernhardt, V. L.

APPENDIX E

STEM PROGRAM ADMINISTRATOR SURVEY

SD = Strongly Disagree, D = Disagree, N = Neutral, A = Agree, SA = Strongly Agree

STEM Program Components	SD	D	N	A	SA
Does the integrative STEM program provide evidence of administrative and school board support?					
Does the integrative STEM program plan incorporate a mission statement?					
Does the integrative STEM program plan select or develop a coherent set of standards and curriculum that is based on National STEM Goals?					
Does the integrative STEM program plan select or develop enrichment and support for all students?					
Does the integrative STEM program plan establish a task force or advisory committee?					
Does the integrative STEM program plan facilitate the involvement of parents and the community?					
Does the integrative STEM program have teachers with high capacity to teach STEM discipline and who participate in professional development?					
Does the integrative STEM program have a supportive system of assessment and accountability and plan utilize student learner outcomes as a measure?					
Does the integrative STEM program have adequate instructional time and equal access to high-quality STEM learning opportunities?					

Note. Adapted from Data analysis: For continuous school improvement. New York, NY, 2004. Copyright 2004 by Bernhardt, V. L.

APPENDIX F

ECC OUTCOME SURVEYS

Student ECC Outcome Survey

SD = Strongly Disagree, D = Disagree, N = Neutral, A = Agree, SA = Strongly Agree

Engagement	SD	D	N	A	SA
1. I like the Griffin High integrative STEM Academy.	1	2	3	4	5
2. The integrative STEM activities are most interesting to me.					
3. My behavior has improved because of the integrative STEM program.					
4. The behavior of your classmates improved as a result of this program.					
5. My attendance has improved because of the integrative STEM program.					
6. Griffin High School is different because of the integrative STEM program.					
Capacity					
1. What do you wish was different in this academy.					
2. I have gained new knowledge and facts because of the integrative STEM program.					
3. I have obtained useful information that can apply in choice of career.					
Continuity					
1. This program will make me want to pursue a STEM career.					
2. I have identified new resources and opportunities.					
3. My values and/or attitudes been impacted as a result of the integrative STEM program.					
4. My fellow students have changed thoughts about their career choices.					
5. The integrative STEM program provided an opportunity for me to evaluate existing belief systems as they impact career choice?					

Note. Adapted from Data analysis: For continuous school improvement. New York, NY, 2004. Copyright 2004 by Bernhardt, V. L.

Teacher ECC Outcome Survey

SD = Strongly Disagree, D = Disagree, N = Neutral, A = Agree, SA = Strongly Agree

Engagement	SD	D	N	A	SA
1. It will take much more to improve student STEM learning in this integrative STEM Academy.	1	2	3	4	5
2. The people who developed the program are experts in STEM disciplines.					
3. Data was collected or used to justify the need for your program.					
4. The intended scope of your program is comparable to the demonstrated need.					
5. There are visibly evidence that integrative STEM activities are making a difference in students' engagement.					
Capacity					
1. The staff participated in professional development training in order to appropriately implement the program.					
2. The activities being implemented provide project- and inquiry-based opportunities.					
3. The activities were implemented as planned.					
4. There are activities not being implemented as planned.					
5. Changes are being made to the original plan as the program progressed.					
6. There are more barriers than opportunities that have being experienced since the integrative STEM program was implemented.					
Continuity					
1. What differences are the integrative STEM activities making in students' learning?					
2. All students were targeted to participate.					
3. The response rate of all student groups (gender, race/ethnicity, socioeconomic status) were all the same.					
4. The needs of participants vary with their backgrounds.					
5. There is an overrepresentation and an underrepresentation of some groups based on their backgrounds.					
6. The outreach conducted was opened to all students.					
7. There is a lot of potential to expand the program to 40% of your student population.					
8. The program reached its targeted number of participants.					
9. Participants stayed for the entire program.					
10. There are retention issues.					
11. Enrichment activities (i.e., extracurricular, dual-enrolment, mentorship) are available to foster student continuity in STEM education.					

Note. Adapted from Data analysis: For continuous school improvement. New York, NY, 2004. Copyright 2004 by Bernhardt, V. L.