INVESTIGATING THE IMPACT OF THE INTEGRATED STEM PROGRAM ON STUDENT TEST SCORES IN JAMAICA

by

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WE, THE UNDERSIGNED MEMBERS OF THE COMMITTEE,

HAVE APPROVED THIS DISSERTATION

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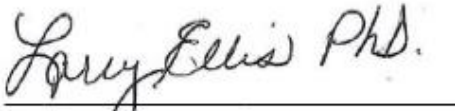

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Abstract

The purpose of this quantitative causal comparative study was to ascertain the effectiveness of the integrated Science Technology Engineering and Mathematics (STEM) program on student achievement scores in Jamaica. This study utilized archival student examination data from 3 years and 2 inner-city high schools, 1 STEM and 1 non-STEM. The study was guided by 3 quantitative research questions with 2 independent variables, school type and gender, and 1 dependent variable, examination scores. The research questions focused on interactions among examination scores, gender, and school type. They also examined differences between males and females, and differences between a STEM and a non-STEM program. A 2-way ANOVA was utilized for the 3 research questions. The results indicated that there were interactions among Caribbean Secondary Examination Certificate (CSEC) scores, gender, and school type. There was also a difference in CSEC scores between males and females. The results of the study also showed that there were differences between a STEM program and a non-STEM program. For the 3 research questions, the results supported the alternate hypotheses, as there were interaction and differences. The results of this study demonstrated that the STEM program has the potential to influence academic scores in Jamaica on a wider scale. Therefore, the utilization of scarce tax payers' dollars to fund the STEM program is showing some evidence of added value.

Dedication

This dissertation is dedicated to my parents who from childhood instilled in me the need to work hard and never give up. Without this kind of upbringing, I would not have completed this dissertation. To my colleagues, Dr. Cole, and Dr. Bailey, a special thank you for the many words of encouragement and motivation that helped me to believe in myself. Thank you to my editor Dr. Skelton. Your efforts, care, and concern were excellent. I really appreciated your strategy of helping me to produce high-quality work. To my colleagues at work who kept checking on me, monitoring my progress, and ensuring that I stayed on task, thank you from the heart. Finally, thank you to my committee, chaired by Dr. Nalepa, who supported and guided me on this dissertation journey.

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Chapter 1

The Study

Education, according to Smith (2015), is the wise, hopeful, and respectful cultivation of learning undertaken in the belief that all should have the chance to share in life. Smith (2015) also asserted that education is a systematic process through which a child or an adult acquires knowledge, experience, skill, and healthy attitude, which enable them to function appropriately in society. M. Fisher (2013) defined education as a dynamic process that evolves with changing times and becomes the economic driver of a country. According to Ritz and Fan (2015), education is the cultivation of learning undertaken with the belief that all should have an opportunity to share. The call for improved education continues to be a widely discussed topic (Ritz & Fan, 2015). Many countries around the world, including the major economic powers, have realized that there is need to transform their educational systems. Transforming education increases competitiveness in an environment of innovation and technological advancement (Kergraoch, Meissner, & Vonortas, 2017). Importantly, Ritz and Fan (2015) affirmed that one approach does not fit all. There are several variables to contend with, which include different teaching strategies along with the technology used to create natural contexts for the application of science and mathematics concepts. According to the Association for Supervision and Curriculum Development (2018), education is a whole-child approach that is defined by policies, practices, and relationships among stakeholders such as educators, families, policymakers, and community members. This relationship ensures that each child is healthy, safe, engaged, supported, and challenged.

Although only a third world country and far from being a global economic power, Jamaica has accepted the need for reform in the education system and has already introduced the

Science, Technology, Engineering, and Mathematics (STEM) program. The term STEM describes an interdisciplinary approach to learning where rigorous academic concepts and real-world lessons enable students to apply science, technology, engineering, and mathematics in contexts that make connections among school, community, and the global enterprise (Rogers, Pfaff, Hamilton, & Erkan, 2015). The interdisciplinary approach enhances the development of STEM literacy and the ability to compete in the new economy (Rogers et al., 2015). Some subjects covered under this heading include engineering, biochemistry, biomechanics, chemical engineering, chemistry, computer science, physics, mathematics, neurobiology, and robotics (Slavit, Nelson, & Lesseig, 2016). J. Brown (2012) and English (2016) pointed out that STEM education involves exploring two or more of the STEM subjects. This ultimately leads to the creation of a discipline based on the integration of other disciplinary knowledge into a new whole rather than in bits and pieces (J. Brown, 2012; English, 2016).

Jamaica, as are other countries, is transforming its education system to keep abreast of global changes and to ensure its relevance. The Ministry of Education Youth and Information (MOEYI), determined to achieve its objective of placing greater emphasis on the practical application of STEM in education, embarked on a program of transformation of selected high schools into STEM academies and to incorporate STEM methodology in all schools. This initiative is a strategic response intended not only to reposition MOEYI institutions in a competitive global environment, but also to emphasize the increasing importance of the skills and innovative attitudes and behaviors congruent with STEM education methodology.

Zeidler (2014) and Storksdieck (2016) argued that STEM education is a crucial issue in educational trends. In their view, integrative approaches with the STEM program help to

improve students' learning. Students also need a firm foundation in STEM education to prepare adequately and strategically for college and employment.

Although there is a strong emphasis on STEM and what the economy requires from the education system, STEM education is more profound than just STEM skills, which stakeholders will have to realize. It involves developing problem-solving skills that require proper communication, reading, writing, and critical thinking skills (Ellner, 2015). As Jamaica continues to evolve in the 21st century, STEM education has become more critical than ever (Thwaites, 2015). Thwaites (2015) described that many students are reluctant to engage with STEM because they perceive it to be "difficult and tragically boring" (p. 1). Thwaites also established that STEM classes help students develop soft skills that so many careers need and make them more proficient in STEM-related industries. Other fields recruit graduates with STEM degrees heavily. According to Thwaites (2015), employers see graduates from STEM programs as possessing skills that students from different faculties lack.

The STEM program has the potential to affect every aspect of society. Consequently, students' exposure to these disciplines must be encouraged. Kelley and Knowles (2016) made the point that children are impressionable and curious. Long-lasting enthusiasm can be developed by instilling an interest in STEM at an early age. Jamaican STEM academies attempt to produce graduates who will be open to change and develop habits of lifelong learning. It is a plan that STEM academies will have features, including specialized support staff, private-public partnership, work experience, external funding, work placement, apprenticeship, targeted curricula, and continuous capacity building of staff in addition to an incentivized pay scale. Additionally, all STEM academies will not necessarily be structured the same way but will follow similar curricula.

Kelley and Knowles (2016) stated that the STEM concept is not new. It was introduced as far back as the 1990s. However, according to Kelley and Knowles (2016), educators have not mastered the art of delivering the program. Kelley and Knowles (2016) further stated that the significant benefit that the STEM program provides is that of preparing a workforce that will improve economies and sustain leadership within an ever-changing and expanding economy. Low student and worker productivity, as well as the demand for new skills required to boost economic growth, have prompted educational and industry leaders in Jamaica to renew the discussion on STEM education in the 21st century. Marginson, Tytler, Freeman, and Roberts (2013) noted that in China, mathematics education was compulsory until the end of school, while Singapore and East Asia placed great emphasis on STEM education in secondary and higher education.

Jamaica's 21st century vision for education has outlined key targets that must be met by the education system. Among these targets is producing a globally competitive workforce (Davis, 2004). The MOEYI recently spearheaded the implementation of STEM education in selected high schools. Thwaites (2015) opined that the competency-based training provided by the STEM program should make students in the upper-school Grades 10 and 11 job ready. Students in the lower school would obtain training from a curriculum that will be STEM based.

A recent conference on STEM education hosted by the University of the West Indies, sought to establish a platform of reengineering the traditional education process. West (2013) contended that sustained efforts must be employed to get the STEM initiative to create job growth, accelerated entrepreneurship, and, ultimately, substantial economic development. According to Daniels and Brooker (2014), graduates' work-readiness attributes must be assessed

in terms of the "employability skills developed by institutions and embedded into the curricula" (p. 2).

Background to the Problem

A new World Bank study pointed out that 75% of Jamaica's workforce does not possess the necessary skills to function appropriately in the different areas of the modern economy, such as engineering, construction, manufacturing, and technological advancement (World Bank, 2011). According to the Jamaica Gleaner (2013), Professor Packer, a well-known educator in Jamaica intimated that STEM education in Jamaica receives insufficient attention and as a result the nation's survival in a knowledge-based economy becomes shaky. He went on to state that the country needed more of the type of STEM education that would put the country on a path of development (Jamaica Gleaner, 2013).

Jamaica operates within a global context, which dictates that it produces graduates with specific capacities who can compete and be productive citizens when compared to their counterparts in other developed or developing countries (Thwaites, 2015). Many of Jamaica's students achieve poor results in STEM subjects such as mathematics, science, engineering, and information technology (Thwaites, 2015). They display poor work ethic, low self-confidence, and low self-efficacy beliefs. Those students who demonstrate high levels of confidence in their abilities are mostly those who are enrolled in traditional high schools (Thwaites, 2015).

Mullings (2012) contended that Jamaican students are no different than those of other countries. They are exposed to the Internet and television. They also travel to other countries and are exposed to other cultures. Additionally, students must possess self-efficacy to maximize the opportunities that the STEM program provides (Mullings, 2012). Thomas (2017) pointed out that the emphasis the Ministry of Education placed on the STEM program has increased throughout

the years. Ministry officials stated that funds amounting to approximately $385 million Jamaican had been dedicated to the implementation of the program since it was introduced to the education system in 2014.

Bandura (2001) posited that personal agency is central to peoples' beliefs about their capabilities to exercise control over events that affect their lives. According to Bandura (2001), when one is functionally conscious, he or she is deliberately processing information for selecting, constructing, regulating, and evaluating courses of action. Bandura (2001) opined that students' self-efficacy beliefs could be influenced by internal and external sources. Indeed, some teachers' perceptions of self-efficacy beliefs are unfavorable as to students' abilities. Bandura (2001) was clear that verbal and social comments have a significant impact on how students form self-efficacy. According to Bandura (2001), if the reverse of having negative comments is realized, then students' self-efficacy will be affected positively.

Many high school teachers in Jamaica complained that students leaving the primary system are ill-prepared for high school. However, it is essential to remember that students' academic performance is influenced by several factors and not just their educational experience in primary school (Thwaites, 2015). Some of these factors include absenteeism, violence, and proper nutrition.

According to CompTia Research and Marketing Intelligence (2018), in developing a global workforce, the exposure to technology does develop smarter workers who can compete and perform credibly. Jamaica must be careful of being left behind and not able to compete in the global marketplace. As times change, students only need a hand-held device to access the Internet. Students in Jamaica can have increased access to technology that will help them to compete effectively with their counterparts globally (Jamaica Gleaner, 2015).

Problem Statement

Scarce government resources have been used to implement the STEM program in Jamaican high schools (Jamaica Observer, 2015). A taxpayer might ask if the STEM program is having an impact on the workforce or improving the quality of high school graduates who enter STEM vocations at universities. Several national organizations have displayed great interest in the implementation of the STEM program as a means of addressing the poor quality of graduates who seek employment (Jamaica Observer, 2015). Industry players believe that jobs in STEM fields will continue to provide higher earning potential for employees (Jamaica Observer, 2015). There is even greater pressure on the education system to provide talented and skilled youth to fill this demand for skilled workers in the STEM workforce. Therefore, the education system must produce graduates who can adequately function in these jobs (Thwaites, 2015). However, it is not known if achievement scores differ for those integrated into a STEM program compared to those not integrated into a STEM program. Therefore, a quantitative-method approach was utilized to explore the topic and made the findings known.

Not knowing the impact on student achievement scores and the quality of graduates from the STEM program, in terms of sufficiency of knowledge, skills, and job readiness, has the potential for negative consequences. The greatest is the potential for not realizing the measurable return on scarce taxpayer dollars invested. The return on investment is critical, as the country is currently on an International Monetary Fund program where there are budgetary cuts and reallocations (Jamaica Observer, 2015). The country is also expected to be creative and spend wisely. Therefore, without knowing the impact, policymakers may not continue to support the STEM program and channel funds elsewhere. The research for the paper was guided by three quantitative research questions.

Research Questions

Research Question 1: To what extent is there an interaction in Caribbean Secondary Examination Certificate (CSEC) scores between gender and school type?

Research Question 2: To what extent is there a difference in CSEC scores between males versus females?

Research Question 3: To what extent is there a difference in CSEC scores between a STEM and a non-STEM program?

Research Hypotheses

Null and alternate hypotheses. The three null and alternate hypotheses for this study were:

$H1_0$: There is no interaction in CSEC scores between gender and school type.

$H1_a$: There is an interaction in CSEC scores between gender and school type.

$H2_0$: There is no difference in CSEC scores between males versus females.

$H2_a$: There is a difference in CSEC scores between males versus females.

$H3_0$: There is no difference in CSEC scores between a STEM and a non-STEM program.

$H3_a$: There is a difference in CSEC scores between a STEM and a non-STEM program.

Purpose of the Study

The purpose of the study was to determine whether the STEM program has influenced student achievement scores. The study compared STEM subjects' data of student populations in a STEM high school and a non-STEM high school. Research was needed to determine whether the STEM program had an impact on students' academic performance. Policymakers needed to determine whether scarce resources dedicated to the STEM program are having an impact on students' academic performance and can be considered a wise investment. The findings from the

study can help to determine necessary changes to the STEM program as students move through the education system.

Rationale for the Study

The primary motivating factors behind investigating the integrated STEM program and its impact on the academic performance of a selected group of students in Jamaica were extrinsic. One such factor was that the results of this study could be used as a catalyst for the complete transformation of the education system. According to Thwaites (2015), many of Jamaica's young people were resorting to crime and other illegal activities. Some of Jamaica's citizens characterized the education system as not fulfilling its mandate to the country (Thwaites, 2015). Every year a high percentage of taxpayers' dollars goes to the education system in Jamaica. It gets the second-highest allotment from the country's annual budget (Thwaites, 2015). As many of Jamaica's students continue to struggle with the sciences and mathematics, the researcher is hopeful that a new approach to how teachers facilitate the teaching-learning experience will help to improve performance outcomes in the STEM program. The impact of the STEM program and the research findings may be utilized to change the aim and focus of the education system where all students are exposed to STEM education at the different levels of the education system.

Significance of the Study

The research that was conducted on the impact of the STEM program on students' academic achievement could help to improve the overall effectiveness of how the Jamaican education system prepares its students. This study was significant in several ways. First, it determined that there were significant gains in student achievement scores in the STEM program according to gender. Second, the findings from the study will help to form a platform on which

to improve student performance at all levels of the education system in Jamaica in addition to highlighting a return on investment. This is important, as the new National Standards Curriculum being used has aspects of STEM and is currently at the primary and secondary levels in the system. The results of this research may also assist educational and political leaders to develop policies that cater to students' academic needs. The education system is also being scrutinized for the high number of graduates who are unprepared for work or higher education (Thwaites, 2015). Therefore, unearthing the impact of the STEM program on student academic achievement may provide a new approach as to how education is practiced in Jamaica and can also form the basis for future research.

With the introduction of the STEM program in some high schools, the findings of this study will also promote collaboration among Ministry of Education, school principals, teachers, and other stakeholders in directing policy regarding the implementation of the STEM program in other schools in the country.

Most researchers investigating the impact of a STEM program on academic performance have reported a strong correlation (Gnagey & Lavertu, 2016; Honicke & Broadbent, 2016). However, this study investigated the integrated STEM program and its impact on academic achievement in Jamaica. Hence, the findings from this research can be added to the body of literature and provide a link in understanding the impact of the integrated STEM program on academic performance in a third-world country.

Definition of Terms

Academic achievement or (academic) performance: This is the outcome of education—the extent to which a student, teacher, or institution has achieved their educational goals (Stemler, 2012)

Attitude: A settled opinion or way of thinking. It is also a predisposition or a tendency to respond positively or negatively toward an idea, object, person, or situation. Attitude influences an individual's choice of action, and responses to challenges, incentives, and rewards together called stimuli (Attitude, 2012).

CSEC: CSEC is an examination that students who have reached the age of 16 years or older sit yearly in Caribbean countries (Caribbean Examination Council, 2018).

Non-STEM school: This is described as an institution that offers traditional methods of teaching and learning (Mullings, 2012).

Perception: The act of perceiving or the ability to perceive or having insight. In other words, someone can notice, understand, and find meaning in stimuli (Eggen & Kauchak, 2010).

Self-efficacy: This is defined as the component of self-concept that concerns individuals' beliefs in their capabilities and competencies to handle a given task (Schwarzer, 2014).

Self-efficacy belief: One's confidence in his or her abilities to complete a task (Bandura, 2001).

STEM: STEM has been defined as science, technology, engineer, and mathematics. STEM is an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply the different disciplines in contexts that make connections among school, community, and the global enterprise, enabling the development of STEM literacy and the ability to compete in the new economy (R. Brown, Ernst, Clark, Deluca, & Kelly, 2016).

STEM program: A curriculum based on the idea of educating students in four specific disciplines—science, technology, engineering, and mathematics—in an interdisciplinary and applied approach (Mullings, 2012).

STEM school: A school that has a STEM program in place that is characterized by noisy, exuberant classrooms that exemplify what STEM schools represent. Learning is collaborative and project-based; kids work closely together in a hands-on way to solve real-world problems (R. Brown et al., 2016).

Limitations of the Study

The study did not utilize a random selection of high schools. This is because the Ministry of Education had already selected a group of high schools to pilot the STEM program. The study was limited to one STEM and one non-STEM high school. The population included three cohorts of students who were enrolled in Grade 11 throughout three years. The high schools' records kept were examined to glean necessary data.

Delimitations of the Study

The STEM program was introduced to the high school that was a part of this study in 2014. The information used was about students who were enrolled in the STEM program and non-STEM program throughout three years and had to do only with their academic achievement on the CSEC. The two schools that were involved in this study were in the same general area.

Summary

This chapter included an introduction, background, statement of the problem, research questions, research hypotheses, purpose of the study, rationale for the study, significance of the study, the definition of terms, and limitations to the study. The chapter outlined a clear justification for examining the STEM program and its impact on students' academic achievement in the CSEC program. This chapter provided detailed information on the context in which the Jamaican education system operates.

The introduction provided an overview of the Jamaican education system and the need for change. Following the introduction, the background of the study provided an overview of the quality of Jamaica's workforce and the current state of the education system and the outputs that were realized. After the background, the statement of the problem brought into sharp focus that scarce taxpayers' dollars were being spent on the STEM program. A taxpayer might ask if the STEM program provided value for the extra resources dedicated. This question led to the purpose of the study, which was to examine the impact of the STEM program on students' academic achievement.

The research was guided by three research questions with coordinating hypotheses. Next, the purpose of the study was to determine if the STEM program had an impact on student academic achievement. After the purpose section, the rationale of the study indicated that many of Jamaica's youth were resorting to crime and illegal activities, as it was felt that the education system was failing them. Scarce resources were being spent on the STEM program and it was not known if there was value for extra money.

The study was subdivided into five chapters. Chapter one included an introduction of the study, where an overview of the problem was highlighted. This chapter also included a background, problem statement, rationale for the study, the purpose of the study, the significance of the study, and key term definitions.

Chapter 2

Literature Review

Jamaica's education policymakers see the need for urgent reform to achieve the 2030 vision of becoming a first-world country. Every dollar spent in the economy causes a strain on taxpayers. The education system is expected to produce high-quality graduates to add to the country's economic outlook. Chapter 2 covers pertinent literature that relates to STEM education.

This chapter explored literature on STEM education in Jamaica, including (a) overview of the Jamaican education system, (b) theoretical framework of the study, (c) self-efficacy and social learning theory, (d) the construct of self-efficacy, (e) factors influencing self-efficacy beliefs, (f) employability and STEM education in Jamaica, (g) career and technical education and STEM, (h) gender and STEM education, (i) challenges with STEM education, (j) institutional readiness and STEM education, (k) perceptions and attitudes toward STEM education, and (l) current status of STEM education research.

Overview of the Jamaican Education System

The four-tiered Jamaican education system comprises early childhood, primary, secondary, and tertiary institutions. In this study, there is interest in the third tier. Many of these high schools are identified as technical, traditional, and newly upgraded. The Jamaican education system is often said to mirror that of England (State University, 2010) in terms of structure and governance.

The Western Carolina University (2001) found that slaves who had become students in Jamaica were forbidden to learn to read and write and were only exposed to some forms of religious knowledge, which led to the Bible as the only reading literature. Many new schools

were established based on this arrangement. As the education system continued to evolve, the idea of technical schools evolved. The authorities felt that not all students were academically inclined, and therefore, there was a need to expose them to skills and technical areas. There are several technical schools that the government proposes to use to expose students to technical vocations. Although well-intentioned, the schools do not offer students a wide range of the technical skills that are required to survive in industries and STEM-related vocations (State University, 2010).

The technical schools resorted to offering some technical areas and many academic subjects. The diverse offering of courses became necessary to meet the needs of the economy (State University, 2010). Education officials examined world trends and began to realize that the system was not producing the quality of graduates that the economy needed to push growth and development. It was, therefore, conceived that the STEM program could be an excellent way to improve on the quality of graduates that the system produced.

Theoretical Framework

Bandura's (1977) Social Learning Theory, Maslow's (1943) Theory of Motivation, Vroom's (1964) Expectancy Theories, and Gardener's (1983) Multiple Intelligences underpin this research. Several researchers throughout the years, such as Linnenbrink and Pintrich (2002); Schunk, Pintrich, and Meece (2008); and Patrick, Ryan, and Kaplan (2007), have argued that motivation plays a critical role as students go through the many classroom experiences with persistence, effort, and choice. The link between academic achievement and motivation in learning and performance is well established through the psychological theory on achievement motivation. The contemporary theories that were chosen for this study build on the view that individuals are active meaning makers of the experiences and situations around them. Likewise,

in the classroom, students actively form perceptions through their work, autonomy given to them, their relationships with adults and peers, and their expectancies for success (Schunk et al., 2008). These reasons form the basis of selecting Bandura's (1977) Social Learning Theory, Maslow's (1943) Theory of Motivation, Vroom's (1964) Expectancy Theories, and Gardener's (1983) Multiple Intelligences as the theoretical framework of this study.

Bandura (1977a) purported that human beings learn from one another through observation, imitation, and modeling. According to Sternberg and Williams (2010), this theory is a bridge between behaviorist and cognitive learning theories because it encompasses attention, memory, and motivation. Bandura (1977a) explained that human beings learn through observing the behavior, attitudes, and outcomes observed around them. According to Bandura (1977a), from observing others, it is easy to form ideas of how new behaviors are performed and then use this information to guide future actions. Bandura (1977a) also pointed out, "Man's capacity to learn by observation enables him to acquire large, integrated units of behavior by example without having to build up the patterns gradually by tedious trial and error" (p. 2).

Bandura (1977a) also stated that for effective modeling to take place, there must be attention, retention, reproduction, and motivation to repeat observed actions. One has to be able to pay attention to what is happening around him or her. However, various factors can either increase or decrease the effectiveness of attention. These include affective valence, prevalence, complexity, functional value, one's sensory capacities, arousal levels, perceptual set, and past reinforcement (Bandura, 1977a). Likewise, being able to remember what was paid attention to can be aided by symbolic coding, mental images, cognitive organization, symbolic rehearsal, and motor rehearsal. Reproducing images depends on physical capabilities and self-observation of reproduction. Last, according to Bandura (1977a), motivation requires having a good reason to

imitate what hinges on three main pillars: past-traditional behaviorism, promised–imagined incentives, and vicarious–seeing and recalling the reinforced model. Bandura (1977a) also believed that new patterns of behavior could be acquired through direct experience or by observing the behavior of others.

Maslow's motivation theory is well known and highly regarded as an influential theory in motivating people at the workplace (as cited in Jerome, 2013). Maslow, who purported that human beings have a hierarchy of needs, developed this theory in the 1940s. Maslow represented his theory in a pyramidal format that shows basic needs at the bottom and more complex needs at the top. Maslow's theory of motivation has five levels: (a) physiological needs—hunger, thirst, and sleep; (b) safety needs—security, protection from danger, and freedom from pain; (c) social needs—friendship, giving and receiving love, and engaging in social activities; (d) esteem needs—self-respect and the esteem of others, self-confidence and achievement, and recognition and appreciation; and (e) self-actualization—the desire to develop and realize full potential (Jerome, 2013). In general, as achievement of one set of needs takes place, the next level of needs becomes more of a motivator.

The theory of multiple intelligences is a learning theory that quickly helps to merge learning styles and technology effectively (Gardener, 1983). This theory was developed by Gardener in 1983 and described at length in his book, *Frames of Mind: The Theory of Multiple Intelligences*. It is embedded in the constructivist approach to learning and suggested that people possess several intelligences learners use to process and interpret information. Gardener (1983) listed seven intelligences: linguistic, logical-mathematical, spatial, musical, bodily-kinetic, interpersonal, and intrapersonal. Since that time, he added naturalistic and a possible existentialist. The theory of multiple intelligences fits well with the century's plethora of

technologies. In other words, it is a theory that is easily adapted to facilitate technology integration in the classroom (Gardener, 2006).

According to Gardener (2006), linguistic learners stand out because they can excel in oral and written communication. Numbers, pattern recognition, relationships, questioning, and exploration fascinate logical-mathematical learners. Surroundings and environment influence spatial learners' capacity to function (Gardener, 2006). Those who are musically inclined tend to learn best while they are listening to music or creating rhythms and patterns. Kinesthetic learners are acutely aware of the roles their bodies play in learning. They enjoy movement and dance by using their mental abilities to control body movement (Gardener, 2006). Interpersonal learners are great at conversation; they are incredibly social and are fully aware of the feelings of others. Intrapersonal learners are very self-aware; they are great at motivating themselves with sharp meta-cognitive skills (Gardener, 2006). The naturalistic learner makes a connection with the content and the natural world. The existentialist is one who focuses on the big picture and why the world operates the way it does (Gardener, 2006).

The education system, as envisioned by Gardener (1983), is expected to develop intelligences and to help people achieve their academic potential through different access points. According to Gardener (1983), when people are exposed to differentiation, they feel more engaged, valued, and have a sense of achievement. Acceptance of Gardener's multiple intelligences theory would result in a broad vision for education. It requires teachers to use different methodologies and activities with their students. Research has shown that creativity and innovation in the classroom make great sense to educators. Besides, not every child learns the same way (Macblain, 2014). In Jamaica, it is being stressed for teachers to utilize differentiated instruction in their lessons to reach all the students at all levels (Thwaites, 2015). Acceptance of

Gardener's multiple intelligences would result in more students being engaged in the teaching-learning process, causing more authentic learning to take place. According to Thwaites (2015), a community of learners where everyone feels confident and respected for their learning talent, also will be realized.

Self-Efficacy and Social Learning Theory

Self-efficacy, as we know it, was developed by Bandura as part of a more extensive learning theory, which over time, developed into the cognitive learning theory (Schwarzer, 2014). Self-efficacy refers to perceived capabilities for learning or performing actions at designated levels. Since its introduction by Bandura in 1971, researchers have explored its role in various domains, including education, business, athletics, careers, health, and wellness. There is no denying that self-efficacy is a useful tool in motivating individuals to achieve and enhance self-regulation (Schwarzer, 2014). While generating ideas about this phenomenon, Bandura (1977a) established that social cognitive theory and human functioning result from the dynamic interplay among personal, behavioral, and environmental influences. Social cognitive theory encapsulates the understanding of human agency in which individuals are proactively engaged as they develop and determine their actions (Schwarzer, 2014). Ranking high on the list of expected outcomes is the ability to learn through experiences, self-regulate, and self-reflect. Self-efficacy, according to Bandura (1971), influences behaviors and environments that produce similar effects on self-efficacy. Individuals can develop self-efficacy beliefs because of social persuasions they can acquire from physiological and emotional states. Besides, self-efficacy information is not directly translated into judgments, as it is not the only influence on behavior. According to Schwarzer (2014), both teachers and students utilize self-efficacy. Teachers with higher self-efficacy also are often seen to develop more challenging activities for students to help them

succeed. Besides, if a student possesses high self-efficacy, but lacks the necessary skills to succeed, other variables intervene, which may prevent the achievement of high academic scores.

Bandura (1977a) pointed out that there has been an acceleration in scientific advances that have resulted in the enhanced methodological development of assessment tools for critical determinants of human functioning. Logically, the quality of assessment provides the basis for stringent empirical tests of the theory. In his observations, Bandura (1971) concluded that human behavior could be conditioned and contextualized. It is, therefore, appropriate for self-efficacy assessment to be tailored to domains of functioning and task demands identifying patterns of strengths and limitations in perceived capability (Bandura, 1977b). This type of refined assessment provides guidelines for tailoring programs to individual needs that can increase production.

Bandura (1977a) purported that if the value of a psychological theory does not possess explanatory and predictive power in addition to the operational power to effect change, then it is useless. However, psychological procedures can alter the level and strength of self-efficacy. According to Bandura (1977b), expectations of personal efficacy come from four principal sources of information: performance accomplishments, vicarious experience, verbal persuasion, and physiological states. Perceived self-efficacy is embedded in a broader theory of human agency that specifies the sources of self-efficacy beliefs and identifies the processes through which they produce their diverse effects (Bandura, 1977b). Several factors that have been identified as influencing the cognitive processing of efficacy information have to do with enactive, vicarious, exhortative, and emotive sources. Knowing how to build a sense of efficacy and how it works provide further guidelines for structuring experiences that enable people to be real. Bandura (1977b) also believed that changes in behavior produced by stimuli could either

signify events to come or indicate probable response consequences. It has also been shown to rely heavily on cognitive representations of contingencies.

According to Schwarzer (2014) and Cherry (2017), self-efficacy can affect academic performance and independent ability levels. Dishonest feedback can also alter the perceived effect of self-efficacy when the performance does not match feedback (Schwarzer, 2014). Sometimes spurious comparisons are made that thwart the true reflection of self-efficacy on a person or a situation. Schwarzer (2014) also pointed out that self-beliefs of efficacy affect thought patterns that can enhance or undermine performance. The stronger the perceived self-efficacy, the higher the goals people set for themselves and then hold an ever-firm commitment to them. Some of the simple things in life, which seem to be unimportant, have become doors of opportunities. Although it is not always good to compare a person' s performance with others, Cherry (2017) and Schwarzer (2014) believed that individuals could acquire much information about their capabilities through knowledge of how others perform. The results are used as a gauge in measuring how well goals are achieved. Cherry (2017) and Schwarzer (2014) pointed out that self-efficacy is a tool that can enhance human accomplishment and well-being in many ways. For example, a strong self-efficacy can help people recover from significant setbacks. If people do not believe their actions will produce the desired consequences, then there is little incentive or motivation to participate fully in those actions. Schwarzer (2014) pointed out that not only adults but also children with strong self-efficacy skills have been deemed more effective problem solvers when compared to their peers.

The Construct of Self-Efficacy

Bandura (1977b) pointed out that that self-efficacy is the belief in an individual's own ability to achieve or accomplish something. In effect, the theory points to people attempting

things that they suspect they will be successful at accomplishing and not things at which they think they will fail. People with very high self-efficacy have this strong feeling that they can accomplish difficult tasks. They see them not as threats but challenges that can be mastered. According to Bandura, efficacious people set goals of higher challenges and usually maintain a strong commitment to completing them. If failure seems to be a possibility, they exert more effort and dedication to avoid failure.

Zimmerman and Kitsantas (2014) and Cherry (2017) pointed out that self-efficacy has some distinct characteristics. According to them, self-efficacy focuses on performance capabilities rather than on perceived abilities or personal qualities. Self-efficacy measurements are usually designed to match certain domains. For example, beliefs about performing on a math test may differ from beliefs about a literature examination. Besides, Zimmerman and Kitsantas (2014) and Cherry (2017) also pointed out that self-efficacy measures are designed to be sensitive to variations in performance context such as how noisy or how quiet an area is where the performance will take place. Zimmerman and Kitsantas (2014) and Cherry (2017) also affirmed that self-efficacy is multidimensional because it varies across tasks. Another feature of self-efficacy, according to Cherry (2017) and Ritchie (2016), is its dependence on a mastery criterion of performance over normative or other criteria.

Factors Influencing Self-Efficacy Beliefs

Educators are aware that teachers' self-efficacy can fluctuate drastically as a result of external factors. Some of these factors include salary, professional development, parental support, and institutional support. Although student self-efficacy is the main focus, according to Hasan, Tareq, Hasan, and Islam (2014) and Chen and Yeung (2015), if a teacher is tired and burned-out, then self-efficacy will be affected negatively. This situation of low teacher self-

efficacy has the potential of affecting how well students perform. Chen and Yeung (2015) described collective efficacy as the perception of teachers in a school that the efforts of the faculty as a whole will have a positive effect on student learning. Chen and Yeung (2015) pointed out that a teacher's belief in his or her ability to influence positively student learning is crucial to real success. Hasan et al. (2014) and Chen and Yeung (2015) cautioned that the concept of teacher efficacy has been moved to another level and has developed into the term collective efficacy.

The shared beliefs of teachers can help to shape the normative environment of the school (Lazowski & Hulleman, 2016). Teachers play a pivotal role in any academic program; therefore, it is crucial to get an understanding of the collective teacher efficacy (Lazowski & Hulleman, 2016). Besides, if teachers do not share the vision of implementing a program, it can have negative consequences. Chen and Yeung (2015) saw collective efficacy as being relevant to school leaders. Teachers with strong perceptions of efficacy put more effort into planning lessons, incorporating new ideas, and being more creative and accommodating. Chen and Yeung (2015) postulated that collective teacher efficacy has the power to improve student performance and ameliorate the adverse effects of poverty. In addition, it can also enhance parent–teacher relationships and create a work environment that builds teacher commitment to the school. Chen and Yeung (2015) opined that collective efficacy is relevant and substantial, so researchers are looking at it seriously and are examining actions that school leaders can take to improve on collective teacher efficacy. Some of the factors that help with the understanding of teacher self-efficacy are social persuasion, vicarious experience, natural disposition, and successful experience (Lazowski & Hulleman, 2016), in addition to analysis of a teaching situation and evaluation of self-competencies that play a critical role in understanding teacher self-efficacy.

The teacher's performance outcomes are hinged to consequences that are outlined to the teachers. This link could require more training for teachers or twining teachers to a mentor.

Some factors that affect collective teacher efficacy include the school's socioeconomic status, teachers' experience, and students' prior academic performance. These factors amounted to less than 50% of what Goddard and Skrla (2006) found in their research; therefore, school leaders can tap into other factors that can affect collective teacher efficacy (Goddard & Skrla, 2006). Supovitz and Christman (2003) also suggested that association between teacher collegiality and improved academic achievement is not as straight forward as some stakeholders would think. However, schools that tried to facilitate a discussion that surrounds instructional strategies and student work, did much better than schools that did not facilitate such discussions. Chen and Yeung (2015) concluded that collective efficacy is key to unlocking the existing talents of individual teachers and building their commitment to school success as well as helping teachers feel supported, respected, and being more open to changes.

Many of the factors surrounding the perceptions of self-efficacy beliefs have been hypothesized through four main phenomena (Bandura, 1997). Bandura (1997) affirmed that when students receive manageable tasks, they develop confidence in tackling more challenging ones. Modeling plays a critical role in student efficacy (Rooij, Jansen, & van de Grift, 2017). It is well established that students will observe their peers and compare themselves to them, which can be positive or negative (Rooij et al., 2017). When a child's friend is doing well, it tends to motivate him or her (Rooij et al., 2017). Positive feedback plays a critical role in contributing to student self-efficacy. When feedback from teachers, friends, parents, and other persons that helps students' academic achievement improve, it has a greater impact on students (Warner, Wolf, Spuling, & Wurm, 2017). The final factor is the student's physiological state, such as stress,

mood, fatigue, and anxiety. Bandura (1997) argued that if students feel a sense of fear when approaching tasks, then this will undermine how well they perform. Figure 1 illustrates some of the factors that affect self-efficacy judgments.

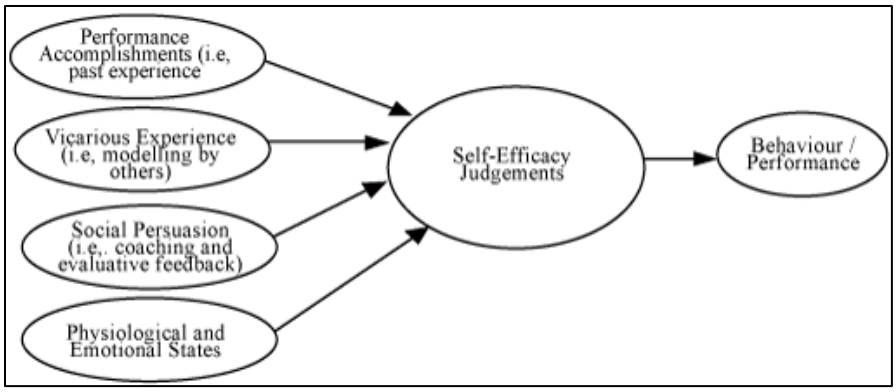

Figure 1. Four factors of influence on student self-efficacy. Adopted from *Psychology of Learning for Instruction* (3rd ed.), by M. P. Driscoll, 2005, p. 318. Copyright 2005 by Allyn & Bacon, New York, NY.

Chen and Yeung (2015) intimated that for teachers to influence students' self-efficacy, the teacher's self-efficacy must relate directly to what they think while they are delivering lessons. According to Chen and Yeung (2015), for teachers to have a defining effect on students' self-efficacy, they must display qualities or attributes of survival, resilience, and innovativeness. Teacher outcome expectation is another crucial area that can be examined to ascertain how teachers think toward their students. Chen and Yeung (2015) were careful to point out that for a teacher to have any effect on students' self-efficacy, the teacher's self-efficacy is a crucial predictor of determining the teacher's actions. Chen and Yeung (2015) were able to outline some of the observable traits of teachers who have high self-efficacy. These teachers were determined in failure situations, took more risks in delivering the curriculum, adopted new teaching approaches, and believed in motivating students to achieve.

Employability and STEM Education in Jamaica

Hunter (2014) reported that Honorable Thwaites, the former Education Minister, outlined the plan of the ministry to introduce STEM academies to the country. Technical schools were expected to move away from preparing students for manufacturing and technical jobs to ones that are technological and innovative in their orientation. This action would be done using curricula that promoted the requisite cognitive, technical, entrepreneurial, and employability skills. The minister intended to have the program deliver a more rounded education.

The former education minister stated that STEM education would foster inquiring minds, logical reasoning, and collaborative skills rather than just recall of facts. In agreeing with the minister, Kleinbach-Sauter, Ganapathy, and Fraser (2015) pointed out that the skilled-based STEM program seeks to help students to graduate from STEM degree programs into STEM fields. Women, girls, and other underrepresented groups are being encouraged to enter STEM fields (Kleinbach-Sauter et al., 2015). Attention is placed on behaviors that are beyond technical skills that enable STEM employees to create stakeholder momentum to commercialize ideas or hone career skills.

In setting the foundation for STEM to be effective, Scherer (2015) highlighted areas such as a change in mind-set and retooling that she believed would help STEM education to be successful. STEM education should involve real-world learning, thus moving away from the traditional obstacles that separate the four disciplines of science, technology, engineering, and mathematics. The new standards of a practical education will help the STEM movement by requiring students to model, analyze, and design items such as toys. Without following a rigid routine or a mechanical construct, students will be able to collaborate, persist at their work, and

learn that second drafts of their written work are part of learning. Scherer (2015) also pointed out that all students need STEM in one way or another.

D. Fisher and Frey (2015) intimated that there is a strong argument being put forward for STEM. In the United States, for example, many are of the view that STEM education will bring about equality among Blacks and Hispanics who are not well represented in STEM high-earning careers (Harrington, 2015). The same is true of Jamaica, based not so much racial distinction but on the kinds of high schools students attend to help to determine the kind of career that they end up in (Kleinbach-Sauter et al., 2015). Preparing students for future employment should not be the only rationale for STEM education. It must help students learn to apply logic and reasoning while solving complex problems. Kleinbach-Sauter et al. (2015) suggested that stakeholders see STEM as a suitable springboard for developing students' communication, collaboration, creativity, and critical-thinking abilities. Flower (2012) pointed out that women and minorities are underrepresented in the STEM subjects. The involvement of women and minorities has significant implications for the future of the STEM workforce in the United States, where a high percentage of the workforce will be women and minorities. Although there is a high number of female graduates from universities, the number who graduate from STEM disciplines is meagre (Harrington, 2015). Flower (2012) pointed out that the United States economy, at least its vitality and productivity, depends heavily on well-trained people who can produce scientific and technical innovations.

According to Kelley and Knowles (2016), one of the primary outcomes of STEM programs in many countries is preparing a workforce that will improve national economies. In Europe, for example, there is a widening gap in STEM skills among the workforce. From as far back as 2004, Building Engineering and Science Talent suggested eight principles that must be

followed to increase student success: institutional leadership, targeted recruitment, engaged faculty, personal attention, peer support, enriched research opportunities, bridging to the next level, and continuous evaluation. These eight principles are crucial for success in the STEM program (Flower, 2012).

The National Science Teachers Association (2016) affirmed that, although STEM education is the way forward, educators are challenged to offer rigorous and engaging STEM lessons to all students. Collaboration forms a critical part of the STEM initiative from stakeholders and students within the classroom. The National Science Teachers Association pointed out what teachers observed in their classes. Teachers observed students working together and developing collaboration skills that they will use as lifelong tools in solving real-world problems. This collaboration permeated throughout the school, where strategies were developed to help teachers share materials that helped the program be successful. It also led to a change in how the teachers taught and how the students learned, with field trips being a pillar in linking STEM-related industries and companies.

Career and Technical Education and STEM

McIntosh (2013) and the National Foundation for Educational Research (2015) suggested that the need for technical education is paramount since relevant and valuable careers do not only come from completing a four-year college degree program. According to McIntosh (2013), career readiness must continue to be highlighted. In making sense of the term, work smart; not hard, McIntosh (2013) encouraged students to examine skilled-trade careers as an ingenious and desirable path. McIntosh (2013) cited one high school that is making great strides. Brillion High School is a school where teachers are trying to push students to see the value of career and technical education. Brillion High School has more than 75% of its population taking Career and

Technical Education courses. According to McIntosh (2013), the school staff has seen an increase in female enrollment. By taking this approach, Brillion High School has managed to change the views of students that hands-on learning and problem solving can help them to be prepared for almost any kind of job.

Shadoian-Gersing (2015) pointed out that the gap that exists in STEM competencies across the labor market is well known. Shadoian-Gersing (2015) opined that a STEM-capable workforce with the requisite knowledge and skills creates individual opportunity and national competitiveness. According to her, gaps are relative in that they can be attributed to a lack of interest on students' part in the STEM program. Shadoian-Gersing (2015) saw the combination of CTE and STEM as strengthening STEM literacy and igniting interest in STEM-related careers among all students. When the content is made more relevant and tangible, the STEM workforce will grow with more underrepresented groups entering various STEM fields (Shadoian-Gersing, 2015). She also saw the need for relevance and integration, which, according to her, inspires students to learn despite diverse learning styles. Immersing a learner in a course where the practical application of technical content in the real-world context can be described as useful is an appropriate strategy. Crucial to the success of STEM education is the emphasis on project- and problem-based learning. This emphasis is essential as it helps to address real-world challenges. Critical to students' future is how the courses are aligned to channel students into postsecondary endeavors, including achieving credentials and setting up a career-ready agenda.

Organization for Economic Co-operation and Development Report (2014) revealed that, when many students failed at reading, writing, and mathematics, they struggled later in life. Failure in these areas highlights the need for the integration of foundational skills with vocational training to give students a second opportunity to acquire mathematical and literacy skills in a

more meaningful and practical context. The report also stated that Washington State utilized a strategy where a program designed to improve labor-market outcomes and entry rates to professional training has been proved successful and is being introduced in other parts of the country.

Gender and STEM Education

Toglia (2013) believed that although several laws have been passed in the United States outlawing discrimination in education, gender opportunities have never been equal. Toglia's research found that girls and women continue to be underrepresented in CTE and STEM programs. Although allowances have been made in other areas of the school or university life to appease the females in the CTE and STEM areas, not much has changed. Toglia (2013) gave a breakdown of female student enrollment in vocations that usually attract females. In cosmetology, childcare, and health-related courses, more than 85% of students were females. When compared to traditionally male-dominated areas, only 10% or less of the enrollment in heating, air conditioning, refrigeration, welding, electrical engineering, plumbing, and automotive were females. This would be an alarming statistic if one believed that both genders were quickly reaching parity in every area of vocation school (Toglia, 2013).

The United States Department of Commerce (2011) outlined the real benefit of women working in STEM fields. Those who are in STEM jobs earn 33% more than women in non-STEM jobs do. Interestingly, women with a STEM degree are lower in earnings when compared with their male counterparts. The United States Department of Commerce (2011) also revealed that half as many women are working in STEM jobs as might have been expected. This has remained constant during an extended five-year period. By contrast, the Department of Commerce was quick to point out that men without the necessary STEM qualification were more

likely to have a STEM job than women. Only at the doctoral level is there a narrowing in the salary gap. Ireland et al. (2018) pointed out that research has shown that girls' overall attitudes toward science are either less positive than boys' or decline with age. Ireland et al. (2018) also mentioned an intersectionality at which women and girls find themselves underrepresented in the social identity groups in STEM. The fact that many women are not intrigued by STEM offerings brings about a shortfall in the supply of STEM professionals (Ireland et al., 2018).

According to Mason, Bailey, Fascetti, and Sorcinelli (2017) and Levine, Serio, Radarama, Chaudhuri, and Talbert (2015), many experts have attributed the lackluster advancement of women in STEM areas to self-efficacy, institutional culture, discrimination, and bias that limit their participation in science. Mason et al. (2017) and Levine et al. (2015) also attributed child rearing, gender expectations, lifestyle choices, career preferences, and personal choice among the many factors that continue to affect women's advancement in STEM areas. Those who see discrimination as a factor look to policy initiatives for solutions, for example, policies that increase girls' interest in STEM (Anaya, Stafford, & Zamarro, 2017). Those who see institutional culture as a negative factor seek to attract and maintain female students and then create clear and transparent criteria for success (Ireland et al., 2018).

Challenges With STEM Education

Baber (2015) intimated that there had been a deliberate push and advocacy of equal opportunity in STEM fields. However, there are real disparities in STEM participation for ethnic-racial groups who find it quite challenging to complete STEM programs and earn credentials. Baber (2015) pointed out that there is historical prejudice, unequal distribution of opportunities for capable students, and the presence of isolated environments for underrepresented students enrolled in postsecondary STEM programs. According to Baber

(2015), one of the areas of concern is equity. The broad focus of equity is mostly hinged on economic advancement and positioning the United States to take the lead in global competitiveness. The National Science Foundation (2012) revealed that racial disparities are evident in STEM fields. For example, 85% or more of material engineers, earth and ocean scientists, and nuclear engineers are White. Baber (2015) and found that a positive racial climate, pedagogical strategies that promote socially relevant inquiry and collaboration, and frequent high-quality interaction with institutional agents such as faculty and advisors influenced the experiences of minority students. Baber (2015) recommended that an interest-convergence framework can provide a clearer understanding of how embedded norms shape inequalities even in the context of increasing calls for diversity in STEM education.

Johnson (2014) looked at the STEM program and concluded that it is a brilliant idea. However, it has not produced the desired change in student performance, mainly attributed to infrastructure and lack of stakeholder participation. In researching the challenges, progress, and lesson learned, Fullan's (as cited in Johnson, 2014) change theory, is based on seven core premises: (a) motivation, (b) capacity building, (c) learning in context for those enacting reform, (d) capacity to change the broader context, (e) reflective action, (f) tri-level engagement, and (g) persistence and flexibility. Johnson found that for the STEM program to be successful, it must evoke motivation individually and collectively. High on the list of things to be done must be capacity building of human capital to close achievement gaps, in addition to individual and collective group knowledge, resources, and motivation. All those involved in the program—administrators, teachers, and other stakeholders—must learn the fine details of educational reforms. Culture shift is a significant part of this stage, where a careful negotiation of new norms, structures, and processes will be introduced. Change in context involves capacity

building focusing heavily on knowledge and motivation. Reflection action is a crucial component where people take ownership of outcomes. Change in behavior will ultimately lead to a belief in the innovation (Johnson, 2014). The tri-level engagement is crucial to the success of the STEM program. Persistence and flexibility in staying require a strong commitment and an unwavering resolve in seeing the program create successful outcomes.

Zeidler (2014) indicated that an effective STEM program faces several challenges. Among these challenges are additional preparation time for teachers, the need for additional resources, inventory storage, and institutional readiness. Teacher attitudes toward a shift in the style of teaching, how to carry out an authentic assessment, and in an integrated paradigm, teachers find themselves having to learn content with which they might not be comfortable. Zeidler (2014) also found that although these obstacles are real, they can be circumvented with the help of supportive administration, continuous staff development, and other technocrats who focus on the specific needs of teachers transitioning to new ways of teaching. Wang (2013) outlined that since 2010, there has been a steady increase of 3.3% in the employment rate in science and engineering fields. In the future, at least nine of the 10 fastest-growing occupations will depend significantly on math and science training. According to Wang (2013), there is a significant need for STEM graduates to fill these positions. Critically, high school graduates have displayed a lethargic interest in taking up postsecondary scholarships at universities, which warrants the widening of the pool of students who study in STEM disciplines.

Institutional Readiness and STEM Education

Although implementing the STEM program at the high school level is considered a much-needed intervention, there is concern about the transition of students to colleges or taking up employment in STEM areas (Elrod & Kezar, 2017). Many graduates are being judged as not

being college-ready (Elrod & Kezar, 2017). In addition, there are several assessments such as CSEC that are used to measure academic readiness for college. In one research study carried out by Frechtling, Merlino, and Stephenson (2015), it was established that great changes were needed in how schools integrated their structure in delivering the STEM program. They used document reviews, surveys, and case studies, among other tools, to ascertain that there is a necessary need for institutional change. There have been several efforts made to improve STEM education at the tertiary level. Throughout six years, approximately 48% of those who entered STEM programs in colleges left the program by the end of the four-year period. Franco and Patel (2017) carried out research and posited the view that funded educational projects such as STEM programs need discerning leadership that will lead to successful completion. Among some of the critical elements that are important for the STEM program to be successful are the involvement of stakeholders, promoted collaboration, clear communication, and distributed leadership. Franco and Patel (2017) averred that if programs of research were built in a new field, especially that of engineering, innovation must guide the interdisciplinary approach. According to Franco and Patel (2017), school climate represents the underground stream of norms, values, beliefs, traditions, and rituals that have arisen throughout time.

Franco and Patel (2017) found that various teacher practices contribute to high student engagement in the new program and enhance the overall meaningfulness of school for students. For example, internal and external partners were utilized and informed that input was required and valued in the study. They also found that planning and collaboration characterized many of the meetings with stakeholders who were allowed to contribute their ideas to the project. Additionally, the STEM school students viewed staff-student collaborations as equally crucial as

student-student collaborations. Hence, STEM schools made a deliberate effort to facilitate students' voices in the school decision-making process.

Lynch, Peters-Burton, and Ford (2015) stated that there are several innovative STEM approaches that can be employed such as inclusive STEM high schools, "which are stand-alone schools or schools within schools or school programs that accept students on the basis of their interest in STEM rather than on the basis of aptitude or prior achievement" (p. 55). According to Lynch et al. (2015), the characteristics that make these schools stand out are their reputations and rate of student success. For a particular high school, the ninth- and 10th-grade students are allowed to take core STEM classes. The STEM classes help the students complete all required college preparatory math and science courses. Lynch et al. (2015) described how some schools offered the STEM program to their students. For example, in the Denver School of Science and Technology, leaves structural elements inclusive of pipes and light fixtures exposed in some spacious traditional classrooms. A high number of teachers have strong backgrounds in STEM content and experience. With this knowledge and experience, these teachers can immerse themselves into the curriculum, thus making the experience more productive for the student.

According to Lynch et al. (2015), for a STEM school to be exemplary, it must be prepared to develop students' STEM expertise. In addition, 10 critical components must be present for a STEM school to be successful:

> …a stem focused curriculum, reform-based instructional strategies and project-based learning, integrated and innovative technology use, blended formal and informal extended learning opportunities, real-world stem partnerships, early college-level coursework, well-prepared stem teaching staff, inclusive stem mission, responsive administrative structure and supports for underrepresented students. (p. 59)

The STEM high school is critically positioned to help those students who find it difficult to see the relevance of traditional teaching and learning strategies.

For Shumow and Schmidt (2014), students will be better engaged in science classes as they go through the middle grades. According to them, there is a general slump in student performance in science as they progress through the grades. In drawing on practical examples, Shumow and Schmidt (2014) posited the view that students see utility value in what they learn. For example, if they find that learning chemistry can help them to make products such as soap and other useful home products, they are more motivated to use what they learn to solve several problems. Critical to the success of STEM is how skilled teachers are in igniting students' interest in classes and can channel their focus toward STEM careers (Goodwin & Hein, 2014). Schools can consider having some STEM programs on weekends, which are not part of the regular curriculum. However, the weekend classes stand to generate a lot of excitement and enthusiasm. This requires administrators to be creative and innovative in providing stimulating experiences that spark student interest in the STEM disciplines.

The integrated STEM program also hinges on aspects of Vroom's (1964) Expectancy Theory. This theory is based on the belief that behavior, the purpose of which is to maximize pleasure and to minimize pain, results from conscious choices among alternatives. In outlining his expectancy theory, Vroom (1964) pointed out that an employee's performance is based on factors such as personality, skills, knowledge, experience, and abilities. Vroom (1964) used three variables to account for this description: expectancy, instrumentality, and valence. Expectancy can be affected by having the right resources available, having the right skills to do the job, and having the necessary support to get the job done. Instrumentality is the belief that if one performs well, a valued outcome will be received. This can be affected by a clear understanding of the

relationship between performance and outcomes. Confidence in the people who make the decisions on the outcome and transparency of the process that leads to the outcome are also crucial. Valence is the importance the individual places upon the expected outcome. Understanding the three elements is critical in choosing one over another, as they are clearly defined as effort-performance expectancy (E > P expectancy) and performance-outcome expectancy (P > O expectancy).

Perceptions and Attitudes Toward STEM Education

Microsoft Corporation (2011) surveyed to ascertain the perceptions and attitudes that parents and students have of STEM education in the United States. The survey found that while 93% of parents believed that STEM education should be a priority, only 49% of them believed that it was a top priority for the country. The survey also revealed that approximately half of the number of parents interviewed were enthusiastic about having the children enrolled in STEM programs but were not willing to spend extra funds in helping them to be successful in mathematics and science classes. Students in college pursuing STEM degrees were asked when they started to believe that they would embark on a STEM academic path. While many said the decision started before college, and others said in high school, only 21% stated that it started in middle school (Microsoft Corporation, 2011). The survey also found that male students were more inclined to pursue STEM because they enjoyed games, toys, and machines more than with their female counterparts. The survey also found that there was a split between the mother and father concerning the career path of their children. Among dads, 57% preferred their children pursue a STEM career compared to only 44% of moms.

Cinar, Pirasa, Uzun, and Erenler (2016) reported that the positive approaches of individuals toward natural sciences, technology, engineering, and mathematics become an

encouraging factor for a future career in STEM. For those who lose interest, it could be a result of the discrepancy between the primary and secondary levels where the subjects are taught with a disciplinary approach when compared to interdisciplinary in primary school. It was revealed that it is a widely held view that males are generally expected to pursue STEM interest when compared to girls. Vennix, den Brok, and Taconis (2017) found that when teachers and students work with companies and other external institutions, students are motivated to challenge STEM domains. They also found that, generally, teachers had a more positive outlook of STEM education when compared with their students. Teachers are fully cognizant that whatever goes on in the classroom must have some connection with 21st century requirements in the workplace. The Institution of Engineering and Technology (2008) published a report on the barriers to STEM education. It highlighted some negative perceptions, such as the belief that STEM subjects are complicated and, if students excel at them, they are considered a nerd or a geek. It was established in the report that several factors, such as learning and teaching methods, curriculum offerings, and assessment, help influence the formation of student attitudes toward science. It was also established that good teaching has the potential to help students develop a positive attitude toward STEM.

The media, parents, and teachers all play a crucial role in influencing students' attitudes towards STEM. Holmlund, Lesseig, and Slavit (2018) pointed out that inherent in STEM education is the opportunity for students to develop 21st century skills such as collaboration, critical thinking, creativity, accountability, persistence, and leadership. These opportunities are embedded in problem- and project-based learning, which help students to make connections among school learning, problem solving, and their careers. According to Holmlund et al. (2018), STEM education benefits from community connections among STEM professionals,

professionals related to STEM and informal science teachers, along with support from parents, community professionals, and administrators. Shernoff, Sinha, Bressler, and Ginsburg (2017) looked at some challenges with integrating STEM education. Among these challenges is the reality that many teachers were trained in one of the disciplines in STEM, and students still had separate departments and timetabled sessions for STEM subjects. Shernoff et al. (2017) pointed out that for a school to work around these issues, a needs assessment becomes a necessary tool to enhance data-driven decisions that benefit the schools, teachers, and students. Several researchers, including Moore and Smith (2014), Glancy et al. (2014), and Guzey, Moore, and Harwell (2016) provided some empirical support for the proposition that engineering is an essential bond or connector that can integrate STEM disciplines in K-12 education. It can also facilitate problem solving, critical thinking, communication and teamwork skills, positive motivation, and attitudes toward STEM careers. This framework can be used as a road map for schools that are determined to integrate STEM subjects.

STEM and Non-STEM Students

Maltese and Copper (2017) affirmed that there is a disparity between sexes in the STEM fields, with far more males pursuing degrees in STEM when compared to females. For this glaring gap to be narrowed, the factors that are critical to maintaining interest in the STEM field must be carefully understood. Students move in and out of STEM pathways; however, self-driven interest is one of the main factors that keep students interested in STEM fields, with support from others also playing a crucial part. Maltese and Copper (2017) also pointed out that student interest in STEM course work, informal experiences, and career options play a significant role in the attitude displayed toward STEM. The Social Cognitive Career Theory (SCCT) was highlighted by Maltese and Copper (2017) as being useful in explaining why

attitudes, interest, and engagement play critical roles in students' decisions to pursue STEM subjects.

Anaya et al. (2017) indicated it has been a policy position to motivate and encourage women into STEM fields. This has become necessary because as far back as kindergarten and early elementary school experiences, a gap begins to emerge in mathematics between males and females. The research also shows that as they go through the grades, the gap widens to the point that when university enrollment data are examined, more non-STEM women are enrolled when compared to men. Nollenberger and Rodriguez-Planas (2017) postulated that gaps between the genders could be traced to the views and social norms held by parents that influence their children's academic motivation, which results in the manifestation of their performance on mathematics and science tests.

Current Status of STEM Education Research

J. Brown (2012) affirmed that STEM education includes approaches that surround any two of the disciplines covered in the STEM subject areas. Merrill and Daugherty (2009) defined STEM as:

> A standards-based, meta discipline residing at the school level where all teachers especially science, technology, engineering, and mathematics (STEM) teachers take an integrated approach to teaching and learning, where discipline-specific content is not divided but addressed and treated as one dynamic, fluid study. (p. 1)

In researching the status of STEM education, J. Brown (2012) found that STEM research was being done in several states in the United States of America. He also found that there is great latitude for STEM research to take place in STEM education at research institutions as well as teaching-focused universities. LaForce et al. (2016) carried out a study on the eight elements of

inclusive STEM high schools and found that school identity was rooted in the transferrable skills, pedagogy, school culture, and rigorous instruction across all subjects. LaForce's et al. (2016) view is one of the views that the interest in STEM schools is high when these qualities are present in schools. Therefore, there is an urgent need to understand how they affect student outcomes. This becomes critical when the impact can be narrowed to certain areas.

Slavit et al. (2016) found that teachers must make sense of a school vision concerning STEM instruction to make the best experience for their students. Collaboration among teachers played a crucial role in the STEM program. They also found that teachers developed a vision and created conditions to develop the curriculum to move in that direction. Corlu, Capraro, and Capraro (2014) also found that the STEM program was characterized by specially planned electives and unique delivery methods of course materials. Besides, curriculum integration provides the theoretical framework for STEM education, which leads to more significant learning outcomes in school subjects. Corlu et al. (2014) pointed out that the better quality of STEM teachers will result in students learning 21st century skills and the capacity to innovate.

Zaniewski and Reinholz (2016) pointed out that mentoring plays a pivotal role in many fields, and STEM is no different. Forming friendships and sharing can lead to great success in the program. Kelley and Knowles (2016) opined that quite frequently, STEM educators have been found to lack a cohesive understanding of STEM education. Therefore, Kelley and Knowles recommended that a conceptual framework be used to help teachers make connections across the disciplines. According to Kelley and Knowles (2016), coherence is critical in STEM education, as it could be applied to solve global challenges that relate to health and the environment among a myriad of other things. Kelley and Knowles (2016) also pointed out that STEM can be grounded in the situated cognitive theory. Martinez (2013) described situated

cognitive theory as the theory that outlines people's knowledge as embedded in the activity, context, and culture in which it was learned. For example, Martinez (2013) pointed out that a Conceptual Framework for New Science Education Students outlined how an engineering design approach can enhance science education. This is possible because it engenders an atmosphere of inquiry where knowledge can be applied in an authentic situation, drawing upon mathematical reasoning during the process (Martinez, 2013). Wang (2013) cited the SCCT, which underscores the interrelationship among individual, environmental, and behavioral variables that are assumed to undergird one's academic and career choice. The SCCT identifies a particular choice by explaining the results of interest and goals. SCCT also explains barriers to the success of the theoretical framework.

Goodwin and Hein (2014) examined three recent studies that focused on STEM initiatives and arrived at a mixed view as to how successful the initiatives were. One study compared STEM and non-STEM schools in Florida and North Carolina (Hansen, 2014). The second looked at STEM in New York, where students in 30 STEM high schools performed better than those in regular public schools overall (Wiswall, Stiefel, Ellen, & Boccardo, 2014). A third study looked at STEM in Arizona by tracking student achievement of nine STEM charter middle schools and two STEM magnet schools (Judson, 2014). Wiswall et al. (2014) concluded that the results of the program have not been overwhelming in improving student achievement. Another study of 1,250 students from eight selected STEM high schools revealed that 64.9% of graduates went on to obtain a degree in a STEM field (National Research Council, 2011). Research needs to show the outcome of students who attended other high schools, not on the STEM program (National Research Council, 2011). Corlu et al. (2014) alluded to how students were placed in STEM-focus high schools in Turkey. Students were selected based on how they performed on

the standardized multiple-choice tests. This meant that approximately 6% of the entire student body was allowed to be educated in an elite high school. When compared with other countries, Turkey ranked low, giving rise to the view that the majority of the students were not receiving quality education in STEM.

Wolfe and Riggs (2017) carried out a synthesis of existing research on programmatic and institutional approaches observed to advance underrepresented population participation in geosciences. Wolfe and Riggs (2017) found that positive student gains were achieved from relationships with subjects and careers. Mentorship was also found to be effective in helping students to increase their likelihood of attending graduate school in the future. Mentorship was also linked to peer support networks and community building efforts in student engagement and retention in STEM majors.

Simon, Aulls, Dedic, Hubbard, and Hall (2015) carried out a study and found that when instructors support students' autonomy in science classes, positive changes will be observed in student development, especially among males. For female students, the researchers found that the perception of self-efficacy and achievement goals had a direct effect on their emotional well-being and how they make improvements in the STEM disciplines. The researchers were careful to point out that there is space in the science classroom for instructional and intervention methods that promote student motivation. They further argued that female students depend more on this aspect of the teaching-learning process when compared to their male counterparts.

Kezar, Gehrke, and Bernstein-Sierra (2017) explored the effects of learning communities on the success of STEM communities of practice. Knowledge, support, and exemplary models have been described as essential vehicles to bring change for STEM education to be successful. STEM communities involve thousands of faculty members who organize events and publish

newsletters, including resources such as curricular modules, and provide ongoing network opportunities for other faculty and teachers to participate. They advocated that there were positive results from the association. They further argued that for math and science classes, learning communities enhanced student motivation and attitude toward their work. Kezar et al. (2017) alluded further that there is a growing body of scientific evidence suggesting that learning communities enhance underrepresented students' ability to engage and retain, which helps to transform their learning experiences.

Bishop (2015) carried out a study that examined the career aspirations of high school males and females in a STEM program. She found that being in the STEM program and students aspiring toward a career in STEM positively correlated. The study also revealed that males were more likely to aspire to a career in STEM when compared with females. In addition to that, females enrolled in the program were twice as likely to aspire to careers in STEM when compared with females who were not enrolled in the STEM program. Bishop (2015) also argued that males who were not enrolled in the STEM program showed a greater likelihood of aspiring to STEM-related careers than females who were not enrolled.

Tolliver (2016) also carried out a study examining the effects of the implementation of STEM education on fifth-grade math and reading achievement utilizing a quantitative causal-comparative approach. Tolliver (2016) found that few quantitative studies examined the effect of STEM education on student achievement, especially in low-income and high minority elementary schools. The results from the study revealed that STEM education had a more significant impact on reading scores when compared to mathematics scores. It was also interpreted that with a change in pedagogical delivery, students stand a good chance of fulfilling their potential in more creative and productive ways. The study revealed that the STEM program

initiated excitement among teachers and students; however, accomplishing the expectations of implementing such a program would not be simple. A crucial factor in the success of the program was the preparedness of the teachers to deliver the STEM curriculum.

Summary

Bandura (1971), a social theorist, was quite clear in his outlook as to how his developed theory of self-efficacy affects human beings. It weighed heavily on the kind of confidence that students and teachers have within themselves and what they believe they can do. The review of the literature explored the Jamaican education system, giving an overview of its historical development. It also examined several areas that have been joined to STEM education, such as employability, career and technical education, gender, and the current status of STEM education. The review of the literature also explored self-efficacy and social learning theory, the construct of self-efficacy, nature of self-efficacy, and factors influencing self-efficacy.

The theoretical significance of this study was that there has been very little research involving the integrated STEM program and the effects of self-efficacy on students' academic performance. The results of this study build upon existing knowledge of the integrated STEM program in high school settings from a theoretical perspective in that little exploration has taken place. Researchers who have already examined the STEM program in educational institutions did not focus on the impact of the integrated STEM program on academic performance in a developing country's context. The STEM program calls for much-needed resources to be allocated to schools that are delivering the program.

Chapter 3

Methodology

Overview

This chapter provides detailed information and an explanation of the research methodology of the study. It explained the work plan of how the research was conducted, data gathering methods, and administrative and sample selection procedures. The purpose of the study was to determine whether the STEM program has impacted students' achievement scores in the CSEC. The researcher used a quantitative study to collect, analyze, and integrate data to gain a complete understanding of the answers to the research questions.

Research Methods

This study was conducted utilizing quantitative research methods. Creswell (2009) and Mertler and Charles (2008) pointed out that quantitative methods, procedures, concepts, and language in a single study serve the purpose of gaining a better understanding of the identified research problem. Creswell and Clark (2007) also defined the quantitative method approach as a research design with philosophical assumptions that guide the data collection and analysis and approaches in many phases in the research process. The philosophical underpinning, which makes the use of the quantitative method necessary, is pragmatism.

Quantitative methods have several strengths. One strength is that data can be collected in a variety of ways. Hypotheses for quantitative analysis tend to be highly specific, describing transparent relationships between the independent and dependent variables. Bryman and Bell (2015) also pointed out that quantitative methods use deductive logic and are, therefore, more easily viewed as real science and are often perceived as providing stronger empirical evidence

than other research approaches. Findings of quantitative studies are usually easy to present, summarize, compare, and generalize.

A qualitative methodology was not appropriate for this study. A qualitative methodology utilizes questionnaires and interviews in the data collection process. Gay, Mills, and Airasian (2009) and Busk (2014) described qualitative research as a method used to capture or understand people's feelings and experiences. This research sought to confirm hypotheses about differences in Grade 11 student academic achievement and the effect of the integrated STEM program. A quantitative method was the most appropriate to address the hypotheses, unlike qualitative methods, which would generally explore the phenomenon of the integrated STEM program and its impact on student academic performance. With this glaring difference, the researcher chose to use a quantitative method over a qualitative or mixed approach. A mixed method would provide both quantitative and qualitative results; however, this study did not apply this method since a mixed method would utilize a qualitative method, and for this study, the researcher only interacted with numerical and statistical data.

Research Design

In investigating the integrated STEM program and its effects on the academic performance of a group of students in Jamaica, a causal-comparative research design utilizing a quantitative method was used. Busk (2014) and Laerd Statistics (2018) defined a causal-comparative research design as a design that researchers utilize to try and identify the cause or consequences of preexisting variances between individuals or groups. Gay et al. (2009) and Mertler and Charles (2008) stated that a causal-comparative research attempts to determine the causes or reasons for the existing condition. The researcher utilized a causal-comparative design, which used a statistical approach to compare the individual CSEC scores of 11th-grade students

of two inner-city high schools—one STEM and one non-STEM—throughout three years. A nonexperimental causal-comparative approach was utilized to address the three quantitative research questions. Creswell (2014) described a causal-comparative nonexperimental study as one where the investigator compares two or more groups in terms of a cause or independent variable that has already happened. By using a causal-comparative design, the researcher was able to use a statistical approach to analyze the CSEC scores of high school students enrolled in a STEM and a non-STEM program. A causal-comparative design views the present description of a problem as the effects of past causal factors. This framework allows researchers to analyze statistically nonmanipulated variables to establish inferences about differences between independent and dependent variables.

A correlational design would not be appropriate because the study did not seek to examine the relationship between the variables (Busk, 2014). The study did not utilize a quantitative quasi-experimental methodology because it involved random selection and manipulation of independent variables without randomly assigning participants to groups (Gay et al., 2009; Sexana & Jain, 2013). In this research, student success was examined in a natural environment and was not manipulated in any way. Therefore, based on the nature of the research problem and the research questions, the most effective study design was quantitative causal-comparative. Archival data for the independent variables, STEM program and non-STEM program and gender as well as the dependent variable, students' CSEC scores, were examined.

This study, based on the nature of the research questions, called for mathematical and logical results to be utilized to analyze statistically the extent to which CSEC scores differed based on school type (STEM and non-STEM) and gender (male and female). The researcher used a causal-comparative design, as it was appropriate and an effective method for this study as

it offered a nonobtrusive approach to the inquiry. Importantly, this study did not seek to determine causality, but to provide answers to the research questions that focused on interaction and differences. Archival data were utilized in this study for the two independent variables which were school type, which had two levels: STEM and non-STEM; and gender, which also had two levels of males and females; as well as the dependent variable, which is student success in the CSEC. A two-way ANOVA was the most appropriate for this study, as it established if there was an interaction between the two independent variables on the dependent variable. The two-way ANOVA informed whether the effect of one of the independent variables on the dependent variable was the same for all the values of the other independent variable and vice versa. This dissertation had two independent variables and one dependent variable; therefore, the option of using a two-way ANOVA for analysis was appropriate and sound. Table 1 summarizes the research design.

Table 1

Research Design

Research Questions	Independent Variables	Dependent Variable	Type of Test to be used
RQ 1	1. School type: 2 levels—STEM program and non-STEM program 2. Gender—2 levels—males and females	CSEC scores	two-way ANOVA

(continued)

Research Questions	Independent Variables	Dependent Variable	Type of Test to be used
RQ 2	Gender—2 levels—males and females	CSEC scores	two-way ANOVA
RQ 3	School type—2 levels STEM and non-STEM	CSEC scores	two-way ANOVA

Procedures

Conducting a research study required a framework that outlined activities that usually happen logically. The first step was to seek approval from the MOEYI to conduct the study in the schools. The MOEYI established research procedures, and, without prior approval, this study could not have been conducted (see APPENDIX A and APPENDIX B). The researcher was expected to abide by sound ethical principles.

The second step was to conduct a literature review. This included reviewing literature specific to (a) the Jamaican education system; (b) theoretical framework of motivation; (c) self-efficacy and social learning theory; (d) the construct of self-efficacy, and students' self-efficacy; (e) factors influencing self-efficacy beliefs; (f) employability and STEM education in Jamaica; (g) career and technical education and STEM; (h) gender and STEM education; (i) challenges with STEM education; (j) institutional readiness and STEM education; (k) perceptions and attitudes toward STEM education; and (l) current status of STEM education research. A thorough literature review is important to highlight what other researchers have written about the relationship between student self-efficacy and academic achievement and to identify the gap in the knowledge that the study is seeking to supplement.

Obtaining permission from William Howard Taft University's dissertation committee to proceed with the study was the third step in this process. The Institutional Review Board

examined the proposal to see if there was any danger to participants before permission was given to proceed in collecting data. Written permission was received from the Institutional Review Board, after which data were collected.

The fourth step was to identify the sample for this study. The study utilized the entire population of the STEM and non-STEM high schools Grade 11 cohorts throughout three years. Both schools were located in the same geographical area.

Step five was to complete a Data Request Form and submit to the Planning Unit in the MOEYI (see APPENDIX C). This allowed the researcher to obtain multiple data for the population sample. This step was necessary for the quantitative phase of the study. It also gave the Planning Unit adequate notice to retrieve and provide the researcher with sufficient data.

Step six was to receive and examine the data to ensure the data points were included and in a proper format for the research design. Data points examined were the CSEC results throughout three years. When the data points were received, the researcher had the option of requesting additional data; however, after examining the data, it was revealed that what was received was sufficient.

The seventh step was to conduct an initial analysis of the quantitative data guided by the three quantitative research questions. There were two independent variables and one dependent variable in this study. The two independent variables, school type (STEM and non-STEM) and gender (male and female), are nominal variables that take on names or labels. A nominal variable is measured by assigning each individual to a particular group or unit. The dependent variable, students' CSEC scores, is a ratio variable. A ratio variable has properties of ordinal, nominal, and interval variables; however, its measurement scale has a real zero point (Laerd Statistics,

2018). A ratio variable allows for both descriptive and inferential statistics to be applied. The research questions answered were as follows:

Research Questions

RQ1: To what extent is there an interaction in CSEC scores between gender and school type?

RQ2: To what extent is there a difference in CSEC scores between males versus females?

RQ3: To what extent is there a difference in CSEC scores between a STEM and a non-STEM program?

Research Hypotheses

Null and alternate hypotheses. The three null and alternate hypotheses for this study were:

$H1_0$: There is no interaction in CSEC scores between gender and school type.

$H1_a$: There is an interaction in CSEC scores between gender and school type.

$H2_0$: There is no difference in CSEC scores between males versus females.

$H2_a$: There is a difference in CSEC scores between males versus females.

$H3_0$: There is no difference in CSEC scores between a STEM and a non-STEM program.

$H3_a$: There is a difference in CSEC scores between a STEM and a non-STEM program.

Step eight was to conduct a two-way ANOVA to address all three research questions to determine the interaction and main effects among school type, gender, and student academic performance on the CSEC.

Analyses of Quantitative Findings

This step was to analyze the quantitative data that were gathered and then provide a detailed summary based on the three research questions. This step also included a detailed

discussion of the results. The final step made conclusions and recommendations regarding the findings to expand the field on the topic of the integrated STEM program and its impact on achievement scores in Jamaica.

Population and Sample

The research focused on adolescents enrolled in the STEM program and those in the non-STEM program. According to the Ministry of Education School Profile (STEM profile) and the schools' report, there were 2,995 students comprising 1,375 males and 1,620 females involved in a STEM Programme who took the CSEC during the past three years. Additionally, the non-STEM school located close to the STEM school accounted for 4,539 students with 1,951 males and 2,588 females who took the CSEC during the past three years. The population for the study was 7,534 Grade 11 students in the STEM and non-STEM schools throughout three years. Data for a total of 7,534 students with 3,326 males and 4,208 females were examined. Utilizing the entire population added statistical strength to the study.

Data Collection

The research method that was employed in this research study included the quantitative research method, techniques, and approaches used to gather data to answer the research questions. To examine the STEM program and its impact on academic performance of a selected group of students that has been through the STEM program throughout three years compared with non-STEM students during the same period in Jamaica, it was practical to explore these techniques. A data request form was completed and submitted to the Planning Unit in the MOEYI (see APPENDIX C). This allowed the researcher to obtain multiple data for the sample. This action was important for the quantitative phase of the study. It also gave the Planning Unit adequate notice to retrieve and provide the researcher with sufficient data. Descriptive data,

different subjects that students were exposed to during their course of study were also received. Grouping of the CSEC data was done to reflect STEM–female STEM–male, non-STEM–male, and non-STEM–female.

Test Academic Performance on STEM Subjects

To gather information to answer the research questions, which referred to the impact of the STEM program on students' academic performance, the researcher used students' CSEC sheet results throughout three years. The CSEC raw scores were utilized for analysis. Examination scores of 50 and above considered a pass, while scores 49 and below were considered failure. The scores that were obtained from this mark sheet were considered valid because they were kept securely by the authorities and administered under standardized examination conditions and had no biases to gender, age, ethnic group, class, or any other factor (MOEYI, 2019). Caribbean Examinations Council (2019) has a robust system of utilizing approved standards of competence as the benchmark of competency standards. This includes facilities audit, relevant curriculum materials, and assessment plans. The Caribbean Examinations Council (2019) also has an established framework for the comparison of evidence against competency standards to establish the performance level of each student. In addition to this framework, there are also provisions for continuous assessment. The management of the assessment process is critical to the examination body. It ensures that the assessments are valid and reliable with the utilization of internal and external verifiers who examine the standard of test items and how examinations are administered. The assessment process also has guidelines that outline the facilities, providing opportunities for authentic assessment of performance. CSEC examinations are administered in the Caribbean annually to measure what students covered in high school in their final two years (Caribbean Examinations Council, 2019).

The MOEYI (2019) also has special accommodations and arrangements for students with special needs sitting for national examinations. These are facilitated after written medical, psycho-educational, and psychological reports are received to support the request. When the reports are received, changes are made to the assessment process, with candidates being given extra time, rest periods, or a separate room. Special accommodations provide candidates with readers, writers, prompters, reader-writers, and translators. Modifications to examination papers include large print, braille, and other changes depending on the need.

Quantitative Analysis

Quantitative data analysis was done using SPSS. Descriptive statistics were used to group students in a range after the data were entered into Microsoft Excel to assess the impact of the STEM program on academic performance. Based on the research questions and research hypotheses, a two-way ANOVA was the most appropriate statistical tool that could be used to determine if there was a difference in the dependent variables for the STEM and non-STEM students' test scores (Laerd Statistics, 2018). For example, a two-way ANOVA was used to understand whether there is a difference between the academic performance of STEM and non-STEM students throughout three years. A two-way ANOVA analysis was run, output from the interaction effect was examined to determine interaction, and the main effect was examined to determine the effect for school type and gender. The null hypotheses were either rejected or accepted based on the significance being p is less than or equal to 0.05.

There are six assumptions for a two-way ANOVA: (a) There must be one dependent variable that is interval or ratio. If the dependent variable is not interval or ratio, then a different statistical test will have to be utilized; (b) The two independent variables, each of which has two or more levels. In this study, the two independent variables were gender with two levels of male

and female and school type with two levels of STEM and non-STEM; (c) There must be independence of observation, which means there is no relationship between observations in each group or between groups; (d) There must be no significant outliers. If there are outliers, an option will be to see if the data can be legitimately deleted depending on the nature of the research. Another option is to continue the analysis with the knowledge that there are outliers and note it in the limitations section. Finally, a transformation of the data can also be done; (e) The dependent variable should be approximately normally distributed for each combination of the groups of the two independent variables. If the two independent variables are not normally distributed, another test can be designed or continue with analysis and make a note of this in the limitation section. Transforming the dependent variable or a separate ANOVA can be utilized; (f) There needs to be homogeneity of variances for each group. If there is no homogeneity of variance, there will be a risk that the output would not be accurate, and this must be stated in the limitations section. If the *p*-value is less than 0.05 the results of the ANOVA are less reliable. In this case, comparing the *p*-values from ANOVA with 0.01 instead of 0.05 is acceptable (Laerd Statistics, 2018).

The first three assumptions must be assessed and met before the final three assumptions are tested. It is also crucial that the statistical tests on these assumptions are correctly done in order not to affect the results of the two-way ANOVA. If data fail any of the assumptions, the data also can be transformed when it is not normal; regardless, the statistical test can be run because the data are quite robust to violating certain assumptions. Alternative statistical tests also can be utilized that do not require the same assumptions to be met.

Ethical Considerations

The researcher has the obligation of (a) maintaining privacy, (b) guaranteeing anonymity, (c) guaranteeing confidentiality, and (d) avoiding harm, betrayal, or deception. Written permission from the MOEYI was sought and obtained to conduct the study (see APPENDIX B). The MOEYI also confirmed that it does not have an Institutional Review Board process in addition to granting permission to conduct research. At no time were students' test data shared with anyone. The data were stored in a safety vault under the purview of the researcher. At the end of five years, the data will be destroyed.

Summary

The purpose of this chapter was to describe the quantitative methodology that was utilized to determine the impact that the integrated STEM program has on student's academic achievement of a group of students in Jamaica as compared to their non-STEM counterparts. The researcher completed a data collection exercise utilizing quantitative techniques to answer the research questions with detail and accuracy.

Chapter 4

Results and Discussion

The problem this researcher addressed is it was not known if, and to what degree, the integrated STEM program and gender have an impact on student achievement scores when compared with students enrolled in a non-STEM program. Many researchers have posited that gaps exist between the genders and how students perform academically (Regner, Steele, Ambady, Thinus-Blanc, & Huguet, 2014). Some link this gap to stereotypes and socialization as to why most males are dominant and females are submissive (Regner et al., 2014). More information on the impact of the integrated STEM program and gender on student achievement scores will help policymakers determine if the country is getting value for scarce taxpayers' dollars allocated to this program. The education system in this country is under scrutiny for the massive chunk of the annual budget that is set aside to fund educational programs such as the STEM program. Additionally, policymakers and industry stakeholders are depending on the education system to produce graduates who can easily fit into the world of work and also access higher education with the necessary 21st century skills (Goodwin & Hein, 2014; Shumow & Schmidt, 2014).

This study utilized a quantitative methodology. Creswell (2009) and Mertler and Charles (2008) described quantitative research as utilizing quantitative methods, procedures, concepts, and language in a single study to gain a better understanding of the identified research problem. Creswell and Clark (2007) also defined the quantitative method approach as a research design with philosophical assumptions that guide the data collection and analysis and approaches in many phases in the research process.

The study addressed the following research questions: (a) To what extent is there an interaction in CSEC scores between gender and school type?; (b) To what extent is there a difference in CSEC scores between males versus females?; (c) To what extent is there a difference in CSEC scores between a STEM and a non-STEM program?

Descriptive Data

This study utilized archival data for enrolled students in the integrated STEM program and the non-STEM program throughout three academic years: (a) 2015–2016, (b) 2016–2017, and (c) 2017–2018. The data were reviewed, and no outliers such as scores that were unusually large or small were found. The data included school type, gender, and students' scores on the CSEC. The academic years in focus along with the variables gave a clear understanding of the nature of the study and the role that each played.

Of the total population of students (N = 7,534) the number of students for which data were received from the Ministry of Education Planning Unit was considerably fewer. Many students also were removed because of missing data. In total, 6,486 students were either missing or removed from the analysis because of lack of examination data. The data for the remaining students (n = 1,848) were utilized in the analysis, which was more than adequate. Of this number, there were 684 STEM students (319 males and 365 females) and 1,164 non-STEM students (589 males and 575 females). The non-STEM high school had more students enrolled in its Grade 11 when compared with the STEM high school.

The data presented used descriptive statistics to explain the key variables under study, which were followed by an analysis of the research questions. The data for the three cohorts of students revealed that more students were enrolled in the academic year 2015–2016, and more females were enrolled in STEM schools in 2016–2017 and 2017–2018. In the non-STEM school,

there were more males in 2015–2016 and 2016–2017. Overall, the non-STEM school had more students enrolled in its Grade 11 cohort (see Table 2).

Table 2

Description of the Sample by Academic Year and School Type

Academic Year	STEM		NON-STEM		TOTAL
	Males	Females	Males	Females	
2015–2016	129	111	272	256	768
2016–2017	100	115	174	155	544
2017–2018	90	139	143	164	536
Total	319	365	589	575	
TOTAL	684		1,164		1,848

The mean examination scores for males were 37.08 and females 40.90. The data in Table 3 revealed that 74% of the males and 61% of females scored 49% and less while scores of 50% and more accounted for 26% males and 39% females. This, therefore, suggests that on average, more students (both males and females) could be reported failing (male = 37.08, female = 40.90). More females scored 50% and more when compared to males, with a difference of 13%.

Table 3

Performance Based on Gender

	CSEC Scores			
Gender	49% & less	50% & over	Mean	Std. Deviation
Males	674 (74%)	234 (26%)	37.08	17.706
Females	579 (61%)	361 (39%)	40.90	19.160

A review of the scores based on school suggests a minimal difference between the students enrolled in STEM and non-STEM schools who can be considered as obtaining a pass. The STEM students accounted for 34% and non-STEM students 31% (Table 4). The scores were not exceptionally high; however, the difference was evident.

Table 4

Performance Based on School

	CSEC Scores			
School Type	Fail (49 & less)	Pass (50 & over)	Mean	Std. Deviation
STEM	451 (66%)	233 (34%)	42.88	14.028
Non-STEM	802 (69%)	352 (31%)	36.76	20.427

A close examination of the data in Table 5 revealed that females had a higher percentage of scores above 50% when compared with males, generally. It must be noted, though, that this was not tested statistically and only serves as a general comment. Interestingly, subjects such as Physics, Information Technology, Industrial Technology (Electrician and Building), and Mechanical Engineering, which are usually male dominated, females had a higher percentage of students scoring 50% and above. Likewise, in subjects such as Electronic Document Preparation and Management and Office Administration, the males had a higher number of scores above 50%. In subjects such as Mathematics, English B, Family and Resource Management, Agricultural Science, and Biology the males had a higher number of scores above 50% (see Table 5).

Table 5

Report on Pass and Fail in Subjects According to Gender

	Male		Female	
Subjects	Pass	Fail	Pass	Fail
Agricultural Science (Double Award)	11 (92%)	1 (8%)	15 (88%)	2 (11%)
Agricultural Science (Single Award)	31 (97%)	1 (3%)	31 (91%)	3 (9%)
Biology	23 (43%)	30 (56%)	50 (31%)	108 (68%)
Building Construction	55 (71%)	22 (29%)	4 (100%)	-
Caribbean History	20 (46%)	24 (55%)	24 (69%)	11 (31%)
Chemistry	8 (10%)	69 (90%)	9 (9%)	94 (91%)
Clothing & Textiles	10 (63%)	6 (38%)	76 (64%)	42 (36%)
Electrical and Electronics	36 (69%)	16 (31%)	4 (80%)	1 (20%)
EDPM	85 (76%)	27 (24%)	264 (84%)	49 (16%)
English A	241 (53%)	216 (47%)	331 (61%)	208 (39%)
English B	12 (60%)	8 (40%)	22 (39%)	35 (61%)
Family and Resource Management	4 (100%)		98 (85%)	18 (16%)
Food and Nutrition	85 (52%)	80 (49%)	261 (75%)	89 (25%)
Geography	16 (18%)	74 (82%)	10 (23%)	33 (77%)
Home Economic Management	6 (100%)		120 (82%)	26 (18%)
Human and Social Biology	18 (32%)	39 (68%)	97 (42%)	132 (58%)

(continued)

Subjects	Male		Female	
	Pass	Fail	Pass	Fail
Industrial Technology (Building)	36 (53%)	32 (47%)	19 (68%)	9 (32%)
Industrial Technology (Electrician)	26 (62%)	16 (38%)	21 (66%)	11 (34%)
Industrial Technology (Mechanical)	96 (53%)	87 (46%)	65 (42%)	90 (58%)
Information Technology	68 (60%)	45 (40%)	63 (61%)	40 (39%)
Integrated Science	74 (53%)	67 (48%)	39 (62%)	24 (38%)
Mathematics	182 (47%)	203 (53%)	88 (32%)	191 (69%)
Mechanical Engineering	41 (80%)	10 (20%)	1 (100%)	
Office Administration	80 (92%)	7 (8%)	131 (89%)	17 (12%)
PE & Sports	41 (79%)	11 (21%)	66 (84%)	13 (17%)
Physics	28 (38%)	45 (62%)	25 (45%)	31 (55%)
Principles of Accounts	45 (53%)	40 (47%)	124 (69%)	57 (32%)
Principles of Business	62 (79%)	17 (22%)	206 (74%)	73 (26%)
Social Studies	58 (42%)	79 (58%)	114 (59%)	79 (41%)
Spanish	11 (31%)	25 (69%)	14 (42%)	19 (58%)
Technical Drawing	79 (42%)	109 (58%)	7 (42%)	9 (58%)
Textile, Clothing and Fashion	22 (51%)	21 (49%)	34 (85%)	6 (15%)
Theatre Arts	18 (35%)	34 (65%)	21 (70%)	9 (30%)
Visual Arts	38 (54%)	33 (47%)	42 (50%)	42 (50%)

According to the data, the academic performance throughout the three years, based on school type, the STEM high school had more scores above 50% than the non-STEM high school, generally. Interestingly, although not a statistical finding, a general comment can be made that the non-STEM high school performed better in Chemistry, Geography, Industrial Technology, and Physics (see Table 6).

Table 6

Report on Pass and Fail in Subjects According to School Type

	STEM		NON-STEM	
Subjects	Pass	Fail	Pass	Fail
Agricultural Science (Double Award)	10 (91%)	1 (9%)	16 (89%)	2 (11%)
Agricultural Science (Single Award)			62 (94%)	4 (6%)
Biology	43 (40%)	65 (60%)	30 (29%)	73 (71%)
Building Construction	39 (78%)	11 (22%)	20 (65%)	11 (36%)
Caribbean History	19 (58%)	14 (42%)	25 (54%)	21 (46%)
Chemistry	11 (7%)	143 (93%)	6 (23%)	20 (77%)
Clothing & Textiles	67 (69%)	30 (31%)	19 (51%)	18 (49%)
Electrical and Electronics	18 (68%)	9 (33%)	19 (51%)	18 (49%)
EDPM	272 (95%)	14 (5%)	77 (55%)	62 (45%)
English A	416 (63%)	249 (37%)	156 (47%)	195 (52%)
English B	10 (26%)	28 (74%)	24 (62%)	15 (39%)

(continued)

	STEM		NON-STEM	
Subjects	Pass	Fail	Pass	Fail
Family and Resource Management	49 (86%)	8 (14%)	53 (54%)	10 (16%)
Food and Nutrition	155 (92%)	14 (8%)	191 (55%)	155 (45%)
Geography	10 (15%)	57 (85%)	16 (24%)	50 (76%)
Home Economic Management	85 (90%)	9 (10%)	41 (71%)	17 (29%)
Human and Social Biology	58 (34%)	99 (63%)	57 (44%)	72 (56%)
Industrial Technology (Building)	11 (39%)	17 (61%)	44 (65%)	24 (35%)
Industrial Technology (Electrician)	9 (36%)	16 (64%)	88 (78%)	11 (22%)
Industrial Technology (Mechanical)	37 (93%)	3 (8%)	124 (42%)	174 (58%)
Information Technology	73 (58%)	54 (43%)	58 (65%)	31 (35%)
Integrated Science	49 (49%)	52 (52%)	64 (62%)	39 (38%)
Mathematics	157 (44%)	201 (56%)	113 (37%)	193(63%)
Mechanical Engineering	42 (81%)	10 (19%)		
Office Administration	143 (86%)	23 (14%)	68 (99%)	1 (1%)
PE & Sports	29 (94%)	2 (7%)	78 (78%)	22 (22%)
Physics	18 (23%)	61 (77%)	35 (70%)	15 (30%)
Principles of Accounts	114 (63%)	66 (37%)	55 (69%)	31 (36%)
Principles of Business	198 (86%)	32 (13%)	90 (55%)	58 (45%)
Social Studies	56 (30%)	128 (70%)	116 (80%)	30 (21%)

(continued)

	STEM		NON-STEM	
Subjects	Pass	Fail	Pass	Fail
Spanish	6 (38%)	10 (63%)	19 (37%)	33 (64%)
Technical Drawing	84 (42%)	116 (58%)	2 (50%)	2 (50%)
Textile, Clothing and Fashion	41 (85%)	7 (14%)	15 (43%)	20 (57%)
Theatre Arts	7 (78%)	2 (22%)	32 (44%)	41 (56%)
Visual Arts	29 (64%)	16 (36%)	51 (46%)	59 (54%)

Data Analysis Procedures

To ascertain the differences of students' academic performance in the STEM and non-STEM high schools with two independent variables—school type and gender and the dependent variable—academic performance on the CSEC, a two-way ANOVA was utilized to answer the three research questions. This statistical procedure was deemed appropriate because the data included variables that were categorical and interval. The two-way ANOVA ascertained if there is an interaction of the independent variables (gender and school type) on the dependent variable (academic performance).

When a two-way ANOVA is used to analyze data, six assumptions must be checked. Assumption 1: The dependent variable should be measured at a continuous level. The scores were kept as a ratio variable. Assumption 2: The two independent variables should each consist of two or more categorical, independent groups; this was met. Assumption 3: There should be independence of observations. This means that there is no relationship between observations in each group or between the groups. Assumption 4: There should be no significant outliers. If there are, they can significantly affect the results. The SPSS software picks up outliers quickly and provides options in dealing with them. Outliers may be ignored if their inclusion can be justified.

Besides, there may be other statistical tests that can be utilized, or the data can be transformed if it is not normal. When the data were cleaned, there were no outliers. Assumption 5: The dependent variable should be approximately normally distributed for each combination of the groups of the two independent variables. This was easily tested using the SPSS software. The Kolmogorov-Smirnov normality test revealed that the scores were not normally distributed. The normality of the data can be violated somewhat; however, robust results can still be produced. Assumption 6: There needs to be homogeneity of variances for each combination of the groups of the two independent variables. The Levene's test for homogeneity was utilized to test for variances. The results revealed that there was homogeneity of variances among the two independent variables (F = 133.928, p = .000).

Results of ANOVA Based on Research Questions

Data for this study were initially intended to be 7,534 students enrolled in both the STEM and non-STEM high schools. However, less data were received from the Ministry of Education. There were also some repeats and some students who did not have any data. When the data was cleaned, the adjusted sample was 1,848.

RQ 1: To what extent is there an interaction in CSEC scores between gender and school type?

A two-way between-groups ANOVA was conducted to investigate the interaction of school type and gender on students' performance in CSEC. There was a statistically significant interaction between gender and school type on students' performance F (1,844) = 18.129, p = .000). The main effect analysis showed that males and females from the STEM school had higher scores than males and females from the non-STEM school (F [1,844] = 27.334, p = .000). The difference in the mean is higher for females attending STEM school when compared with

non-STEM school, accounting for approximately a 10-point difference. For males attending STEM school when compared with males in non-STEM school, there was a two-point difference (Table 7). The STEM school scored significantly higher than the non-STEM school (F [1,844] = 44.383, p = .000). There was a difference in the mean of 5.818, while females scored higher than males (F [1,844] = 27.334, p = .000), with a difference in the mean score of 4.58.

Table 7

Simple Main Effects

	Gender of Students		
School Type	Male	Female	Mean
STEM	38.442	46.751	42.596
Non-STEM	36.336	37.186	36.761
Mean	37.389	41.969	

It can, therefore, be deduced based on the statistical analysis and Figure 2 that females outperformed males in both schools, but more so in the STEM school. The data suggested that there was an interaction between school type and gender based on students' scores. Therefore, the null hypothesis was rejected for RQ 1, and the alternative hypothesis was accepted, which hypothesized that there would be an interaction in CSEC scores between gender and school type. The alternate hypothesis was accepted because there was a statistically significant interaction between gender and school type on students' performance (F [1,844] = 18.129, p = .000).

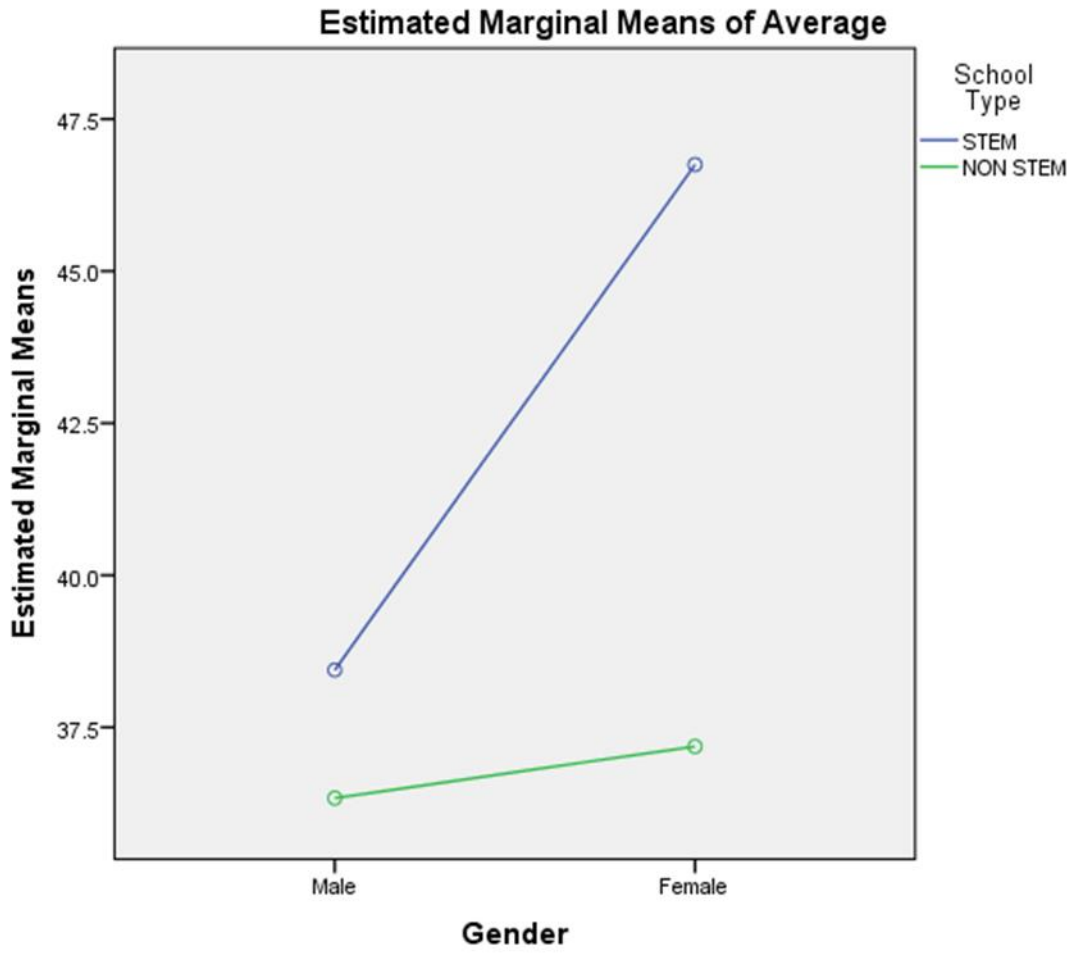

Figure 2. The Interaction of Students' Average Performance in CSEC by Gender and School Type. Figure 2 is the interaction effects from the two-way ANOVA.

RQ 2: To what extent is there a difference in CSEC scores between males versus females?

A two-way ANOVA was utilized for RQ 2. The results showed that there was a significant difference in the scores obtained for males (F [1,844] = 27.334, p = .000). Male scores gave a result of (M = 37.08, SD = 17.71) while females scores gave a result of (M = 40.9, SD = 19.16). Females received higher scores when compared with their male counterparts. Therefore, the null hypothesis was rejected for RQ 2, and the alternate hypothesis accepted because there was a significant difference in scores obtained by males and females.

RQ 3: To what extent is there a difference in CSEC scores between a STEM and a non-STEM program?

The two-way ANOVA test used to determine the difference between the school type and average scores of their CSEC. There was a statistical significant difference in the scores by those attending STEM schools (M = 42.88, SD = 14.03) and non-STEM schools (M = 36.76, SD = 20.43; F [1,844] = 44.383, p = 0.000). The data suggest that students enrolled in the STEM school outperformed the students enrolled in non-STEM schools. Therefore, the null hypothesis was rejected for RQ 3 and the alternate hypothesis accepted because the statistical output revealed that there was a significant difference in CSEC scores between a STEM and a non-STEM program. Table 8 shows the hypotheses and their results.

Table 8

Hypotheses Results

$H1_0$: There is no interaction in CSEC scores between gender and school type.	Rejected
$H1_a$: There is an interaction in CSEC scores between gender and school type.	Accepted
$H2_0$: There is no difference in CSEC scores between males versus females.	Rejected
$H2_a$: There is a difference in CSEC scores between males versus females.	Accepted
$H3_0$: There is no difference in CSEC scores between a STEM and a non-STEM program	Rejected
$H3_a$: There is a difference in CSEC scores between a STEM and a non-STEM program.	Accepted

Summary

In conclusion, analysis of the data in Chapter 4 revealed that there was a statistically significant interaction of school type and gender on students' performance on the CSEC.

Interestingly, according to the data, females outperformed males in both the STEM and non-STEM schools. The analysis of data also revealed that there was a difference in performance between the STEM and non-STEM high schools.

Chapter 5

Conclusions, Implications, and Recommendations

The purpose of this quantitative causal-comparative study was to determine whether the integrated STEM program influenced student achievement scores by comparing students' academic data who were enrolled in the STEM and in non-STEM programs throughout three years. The study addressed three quantitative research questions:

1. To what extent is there an interaction in CSEC scores between gender and school type?
2. To what extent is there a difference in CSEC scores between males versus females?
3. To what extent is there a difference in CSEC scores between a STEM and a non-STEM program?

The integrated STEM program seemed to have impacted students' academic performance positively as they went through the Jamaican education system. This is consistent with related literature that has shown that students' reflective thinking skills toward problem solving have been enhanced. Students' critical-thinking skills also have improved, which helped them to respond to problem scenarios outside of their comfort zones (Sarican & Akgunduz, 2018). Students' 21st century skills that connect to STEM, which are needed to survive in a global economy, have been identified and expanded. These skills include creativity, innovation, problem solving, critical thinking, social, and cultural skills that have been explored by both teachers and students in the integrated STEM program (Sarican & Akgunduz, 2018). This current study aligns with related literature (Corlu et al., 2014; Sarican & Akgunduz, 2018) that outlined that the integrated STEM program, with its blended approach to teaching and learning, along with learning quality and students' interest, will likely increase student academic performance with project-based activities.

The introduction of the integrated STEM program was a measure of bridging the achievement gap that existed in the Jamaican education system. However, the identification of how to fix this achievement gap could not be done overnight but required a change of mind-set and long-term commitment from teachers and the allocation of more resources to the education system. It also required support from professionals with expertise in the STEM areas along with a commitment from administrators. The STEM classroom also differed from the traditional classroom in that in the STEM classroom, inquiry-based instruction was encouraged, which provided opportunities for students to explore concepts and ideas before formal explanations were provided. There were many benefits to be had from utilizing the inquiry-based approach in the teaching-learning experience. It produced growth in practices or processes, which included analyzing data, interpreting graphs, and modeling complex concepts (Marshall, 2015).

Findings and Conclusions

The findings of this study seemed to suggest that the integrated STEM program had some impact on students' test scores in Jamaica. Another important finding from this study was that females outperformed their male counterparts throughout the three years under study. The third finding that can be interpreted from this study was that the STEM high school obtained higher scores than the non-STEM high school. Although there were three major findings from this study, at the same time, there were broad conclusions that were drawn.

First, the results of this study stand a good chance of advancing scientific knowledge by taking steps to understand how the integrated STEM program, school type, and gender affected student academic performance in high schools in Jamaica. Second, the data from this study could be used to provide insights into how the Education Ministry strengthens the STEM program in high schools and introduces the program to other high schools in the country. Third, the results

of this study could also influence the Minister of Education to introduce the integrated STEM program in the other levels of the education system, such as the tertiary, primary, and early childhood levels. Introducing the integrated STEM program at all levels of the education system would send a strong signal to the population that for Jamaica to become a fully developed country, the quality of graduates the education system produces must be on par with other developed countries. Improving the developmental practices from an earlier stage in school life, especially in mastering the 21st-century skills at the early childhood and primary levels, augurs well for the quality of graduates that the system produces.

Fourth, the results from this study can provide a foundation for significant transformation to take place in the education system. Fifth, the results from this study can also help to convince stakeholders that the integrated STEM program could form a platform for developing the country's greatest asset, our people. When the stakeholders buy into the idea of having a STEM-based education system, it will make it easier for the government to allocate more tax dollars to drive this program. This also means that policymakers will have to develop strategies to guarantee that students receive the best educational opportunities that the integrated STEM program has to offer and return value on investment. This study has revealed that an academic program such as the integrated STEM program can do well in a third-world country such as Jamaica. Finally, it can also help students to channel their energy toward other activities in the STEM program, which bring out their creativity and innovative abilities.

Research question 1. After analyzing the data using a two-way ANOVA, it was revealed that there was a statistically significant interaction between gender and school type on students' performance on the CSEC throughout the three years under study. Although the males in the integrated STEM program outperformed their counterparts in a non-STEM program,

interestingly, the females who were enrolled in a STEM program outperformed everybody. The results revealed that females obtained higher scores when compared with their counterparts. Although it is well established (D. Fisher & Frey, 2015) that males usually outperform females in STEM subjects, the females in this study who were enrolled in a STEM program changed the narrative to suggest that students can perform well in just about any subject if they are exposed to the right stimuli. It can also be concluded that the STEM program had a greater impact on females in terms of the academic performance on the CSEC.

The results align with current literature where students who are exposed to the STEM program interact with real-world problems and can make connections among the school community and the global enterprise (Rogers et al., 2015). It also confirmed the view posited by J. Brown (2012) and English (2016) that students perform better when they are taught using the interdisciplinary approach and not bits and pieces. The results also align with arguments proffered by Zeidler (2014) and Storksdieck (2016) that integrative approaches to STEM help to improve students' learning. There is a widely held view that STEM education would most likely suit male students (D. Fisher & Frey, 2015); however, the performance of the females in the STEM program affirmed Kleinbach-Sauter et al. (2015) when they stated that women, girls, and other underrepresented groups are being encouraged to enter STEM fields. Scherer (2015) pointed out that there has to be a rethinking of how we approach education by moving away from the traditional obstacles that separate the four STEM disciplines.

Although there have been other studies that speak to the underrepresentation of women and girls in STEM education and vocation (Ireland et al., 2018; Mason et al., 2017; Toglia, 2013), the results of this study could add to the body of knowledge surrounding females in STEM education and vocation, especially in a third-world country such as Jamaica. The results

of this study showed that students who are exposed to the integrated STEM program can perform as well as their counterparts in other non-STEM high schools. Ireland et al. (2018) affirmed that when students' imagination is channelled in a positive direction, then academic excellence is always near. The literature also acknowledged the critical role that Social Learning Theory played in how people acquire knowledge, which helps to shape behavior. When students are persuaded that they have what it takes to succeed, they will put out more effort to achieve same.

Research question 2. The analysis of data that was done to determine if there is a difference in CSEC scores between males versus females revealed a mixed outcome. The results revealed that males and females enrolled in the integrated STEM program outperformed their counterparts in a non-STEM program. For the academic years being examined, females obtained higher scores overall. The accepted norm was for males to outperform females; however, the results showed the opposite. This sends a signal to the education system and society at-large that females can perform just as well as their male counterparts in STEM subjects. It also means that more females must be encouraged and accommodated in STEM vocations. Moreover, an increase in the number of female teachers in the STEM areas could bolster the image of females and encourage young girls to embark on a career path in the STEM field.

Previous studies were utilized in the review of the literature, and many of them supported the widely held view that males dominate STEM subjects when compared to females. Research carried out by (Anaya et al., 2017) revealed that there was a glaring gap between males and females and their pursuing degrees in STEM areas. One perspective is that as students move through the grades, the academic performance between males and females widens (Anaya et al., 2017). Nollenberger and Rodriguez-Planas (2017) posited the view that differences in academic performance between the genders go as far back as their childhood days where their parents

influenced their social norms. Notwithstanding what these studies have revealed throughout the years, the results of this research challenge the view held by many educational practitioners that males are expected to outperform females who are enrolled in a STEM program. The results showed that females obtained higher scores when compared with their male counterparts. The literature provided evidence that Maslow's Theory of Motivation might have had an impact on students' academic performance. The theory holds that students display intellectual needs, fulfilling potential, and achieving targets. Students' status plays a pivotal role in how they see themselves in comparison to their male counterparts and students in other areas of the country. Achieving academic success helps students to feel a sense of accomplishment, which influences their self-esteem positively.

Research question 3. The two-way ANOVA was used to ascertain if there was a difference between the school type and average scores of their CSEC. According to the results, the STEM school outperformed the non-STEM school. Both males and females who were enrolled in the STEM school obtained higher scores when compared with their counterparts in the non-STEM school. The results of this study, which tried to ascertain if there is a difference in CSEC scores between a STEM and a non-STEM program, align with previous studies conducted. Collaboration among teachers in understanding school vision concerning STEM instruction does have benefits in how students learn (Slavit et al., 2016). Another perspective posited by Corlu et al. (2014) pointed to the STEM program being delivered in an integrated way with specially planned electives and delivery methods, which led to greater learning outcomes. A study of 30 STEM high schools in New York also revealed that students in STEM schools performed better than those in regular public schools overall (Wiswall et al., 2014). The literature also revealed that Gardener's multiple intelligences come in various forms. The

interpersonal and intrapersonal characteristics are critical in how students display their intelligences. For example, in displaying interpersonal intelligence, students are sensitive to moods, feelings, temperaments, motivation, and their ability to work together in groups. Those with intrapersonal intelligence can be introspective, and reflect and evaluate themselves. This is particularly important as students are exposed to the integrated STEM program and what is required for them to be successful.

Implications

There were statistically significant differences in most areas of this study for which many theoretical, practical, and future implications can be created. First, theoretical implications were based on social learning theory, theory of motivation, and multiple intelligences, which were referred to in the review of the literature. There were practical implications that were centered upon creating programs that were attractive to inner-city students, which were able to help them improve their academic performance. Finally, future implications arising from this research were based on building on the findings and creating avenues to explore them further.

Theoretical implications. This study was grounded in the theoretical framework, which focused on social learning theory, the theory of motivation, expectancy theories, and multiple intelligences. Bandura (1971) purported that human beings learn from one another through observation, imitation, and modeling. According to Bandura (1971), if one can observe others, it is easy to form ideas of how new behaviors are performed and later use this information to guide future actions. Maslow (1943) affirmed that motivation plays a critical role in how people perform in the workplace. Maslow (1943) framed his theory into five levels, which have a hierarchical structure ranging from physiological needs, safety needs, social needs, esteem needs, to self-actualization. Finally, Gardener's (1983) theory of multiple intelligences is embedded in

the constructivist approach to learning where learners use several intelligences to process and interpret information.

In this study, the results revealed that school type and gender had an impact on academic performance of students who were enrolled in a STEM program and a non-STEM program. The students in this study may have been affected by the type of lesson delivery and school facilities, including the availability of science laboratories and other facilities, which could have affected how they performed academically. There were also social stigmas connected to the type of school that students attended, whether they were traditional or nontraditional, and whether schools were in the city. There was a perceived bias that traditional high schools obtained better funding from both government and other stakeholders; hence, their students were expected to outperform those from other nontraditional high schools. If students experienced this kind of narrative that their counterparts in other schools were better than they were, then there was a strong possibility that they might believe it and not try as hard to be successful. This was a real cause for concern for educational leaders to create strategies to level the playing field and help students to understand that every child in the education system was equal and deserved the best education that can be afforded them at this time.

Practical implications. This study was conducted in the inner city, and the type of students who were placed at these schools when compared to the traditional high schools could be described as low-performing students. From a practical perspective, the results showed that these students required intervention to support their learning experience, especially activities that focused on skills and interdisciplinary approaches. The results of this study can influence policymakers to establish more STEM high schools in other parts of the country. Based on current research and the results from this study, interventions can be provided to help students

improve their academic performance (Simon et al., 2015). For example, if one gender is outperforming the other, positive changes in delivery can help to fill the gap in terms of extra lessons and free tutoring. STEM learning communities of practice also can be implemented (Kezar et al., 2017). Students' aspirations in high school also play a pivotal role in how they aspire to these careers (Bishop, 2015).

Future implications. For the most part, the results of this study were significant. More insight has been gained into how the STEM program impacted student achievement scores, especially for students in Jamaica who were enrolled in the program. The data from this study, combined with current research, could be used as a foundation for implementing a complete transformation of the Jamaican education system. Future implications include teacher quality, different modes of instruction, school readiness, student self-efficacy, and home support in addressing how best students learn and what grabs their interest as they prepare for the world of work or higher studies. Teacher training will have to be reimagined as the education system embarks on a transformation with the implementation of the integrated STEM program at every level of the system. College courses will have to be adjusted to reflect the STEM approach. This will give teachers entering the classrooms the required skills and competencies to apply effectively this new approach to the teaching and learning process. School readiness is critical to the successful implementation of the integrated STEM program. Schools will need adequate science and information technology labs, smaller class sizes, along with adequate staffing to function effectively. This will ensure that the program will have an opportunity of achieving success. Importantly, student self-efficacy plays a pivotal role in the teaching-learning process. As outlined in the literature, self-efficacy has been proved to be a useful tool in motivating individuals to achieve.

Notwithstanding the presence of self-efficacy to succeed, the presence of other variables such as poor attendance, poor nutrition, and little or no educational materials, along with ineffective teachers, can prevent students from achieving high scores. Home support is critical for students to achieve success in school. It is essential, therefore, that parents attend parent-teacher meetings, supervise students doing assignments, and provide an engaging learning environment at home. This will ease the burden on the school, providing all the learning opportunities that students require to be successful.

Recommendations

The following recommendations resulting from this study were presented in two sections. The first section outlined strategies that can be implemented to transform the Jamaican education system. The second section outlined recommendations for future research.

Recommendations to transform the Jamaican education system. Recommendation 1: The results from this study revealed that females outperformed their male counterparts. The researcher recommends that the education ministry embark on a program of awareness and promotion to increase the number of females who choose STEM subjects. This program could take the form of town hall meetings, advertisements on television and in the newspapers, along with the utilization of social media to reach this critical population. Female students who would have done well in STEM would play a vital role in this promotional and awareness exercise. This would send a message to the country that everybody has a chance to excel in STEM and that the authorities are serious about developing human capital. For this to be highly successful, the education ministry could collaborate with private sector interests to get their input in the awareness exercise and to establish more scholarships that females can access in pursuing further studies in STEM. This would be an excellent initiative, as the country is on a trajectory toward

becoming a developed country, and having more females in STEM vocations would be a significant achievement. This will also significantly reduce the need for employers to look overseas for candidates to fill lucrative jobs in the country.

Recommendation 2: The findings from the study revealed that the STEM program, in general, has a positive impact on students' test scores. The researcher recommends that the integrated STEM program be introduced fully at every level of the education system. This means that the curriculum at the different levels—tertiary, secondary, primary, and early childhood—will have to be updated to reflect the integrated STEM approach, and to include new subjects such as robotics and animation. The introduction of the integrated STEM program at different levels would create a smoother transition for students to enter integrated STEM vocations at higher levels. For example, at the early childhood level and early stimulation for language and literacy, STEM education can start early to immerse the very young and to maximize all the benefits and effectiveness of this new approach. There are implications for teachers already in the system and who were not exposed to a STEM program during their period of training. The education ministry will have to think seriously about establishing a STEM university that would provide the learning space for students to obtain STEM certification at the graduate and postgraduate levels, and for teachers to access training on the job. One possible strategy of establishing a STEM university that the Ministry of Education could explore is to upgrade the HEART Trust Training Institute to a full university. This would save the Ministry of Education from spending unnecessary and scarce resources in establishing a new university. At present, the HEART Trust Training Institute offers skills training in a number of vocations such as plumbing, welding, technology, and auto mechanics to recent high school graduates. Therefore, converting the HEART Trust Training Institute to a full STEM university is feasible and practical.

The STEM university could form working links with other STEM universities in the U.S., Canada, and Australia. This could take the form of visiting professorship, adoption of courses or programs, and student exchange. The STEM university could also form a STEM community of practitioners and learners where creativity, innovation, and problem-solving skills are shared, discussed, and published. Faculty members could also advise students on the right path to excel in STEM vocations. This kind of support will help students connect with undergraduate and postgraduate researchers, and participate in field experiences, internships, and other opportunities that augur well for the STEM sector. The academic and student affairs departments also could work together to develop interventions and mentorship programs to help STEM students achieve success.

In addition to the establishment of a STEM university, the teachers' colleges where most of the nation's teachers are currently trained, will have to modify their programs of study to equip teachers who are entering the education system with the tools that they need to function effectively in a transformed education system. In staying current in the STEM field, the Ministry of Education could mandate that all teachers undertake short courses during the summer period, which would lead to certification in STEM. Improving pedagogical skills is paramount, which would lead to exposing students to the latest trends and help them to keep abreast of innovative changes in STEM field. This would make graduates more marketable and be able to compete with their counterparts globally.

Recommendation 3: The economy and the education system influence each other. Therefore, the education system must produce graduates who can fit easily into a modern economy. Several demands also are made of the education system from time to time, and the system must respond positively. Likewise, the researcher recommends that the government and

the private sector create the environment or form a partnership that will enable graduates to obtain high-paying jobs. This will require the government and private sector to venture into areas of investment and exploration that will help to utilize the innovative skills that the graduates would have acquired during training. This will help to address the brain drain problem that the country is presently experiencing. The environment can be such where graduates can quickly start their businesses and become creators of their wealth. This will require the government and private sector to provide the opportunity for graduates to access loans at low interest rates and extended periods to repay.

Recommendation 4: The results from this study revealed that taxpayers are getting value for their money, and the integrated STEM program is a possible game changer. The researcher recommends that the Jamaican government allocate more money from the national budget to support the integrated STEM program. This recommendation is justified when the performance of the education system throughout the years was examined. There has always been a massive gap in the quality of graduates that is produced. The STEM program has shown that the likelihood of improving students' academic performance and transforming the Jamaican education system is real.

Recommendations for future research. Several recommendations can be made based on the results of this study. The first recommendation is for this present research to be replicated within the next five years. This will allow the researcher to explore further the impact of the integrated STEM program on students' academic performance, especially at the CSEC level. This causal-comparative study must be replicated to establish and substantiate a plausible connection between the effect and its cause. It is also a possibility that there could be a more

significant impact, or the opposite could be that the integrated STEM program is having less of an impact on students' academic performance.

The second recommendation for future research is for a researcher to examine further the effectiveness of the integrated STEM program on student academic performance and how students can maximize their potential by being immersed in a new approach to teaching and learning. This exciting study could reveal several things pertaining to teacher and student attitudes toward the 21st-century classroom and their emerging roles. The researcher could utilize a mixed-methods approach in unearthing the impact of the integrated STEM program, the new approach to teaching and learning, and students maximizing their wide academic potential.

The third recommendation for future research is for the utilization of quantitative correlational research to determine whether, and to what degree, a relation exists between two or more quantifiable variables. In this study, the focus would be on gender, student self-efficacy, and their achievement scores on various examinations in STEM and non-STEM high schools. How students feel about their abilities and what they perceive as educational challenges or barriers and their chances of being successful in school could provide significant insights. This research could extend scientific knowledge also by further exploring student success, if any, and how students feel about themselves and their gender. This could help education policy makers to implement corrective measures to help students improve their academic performance. These corrective measures could include a change in pedagogical practices, assessment practices to include alternate assessment in exit exams, and a change in the minimum requirements for entry into universities.

As outlined in the literature, how we presently practice education in Jamaica is not necessarily producing the kinds of outputs that the country requires. Training of teachers

becomes an issue; the funding of schools according to population and location will also become factors in determining how the education budget is allocated. Training of teachers must become more targeted in areas of emphases. Providing the right training for teachers can serve as a catalyst for transforming the education system. It could also mean that more support programs to boost students' self-efficacy and confidence, such as the School-Wide Positive Behavioral Interventions and Supports be fully introduced to the education system. In brief, the School-Wide Positive Behavioral Interventions and Supports is a universal, school-wide prevention program that aims to establish a social culture within schools in which students expect and support appropriate behavior from one another and thereby create school environments that are socially predictable.

Another recommendation for future research is for the utilization of a qualitative grounded theory study. This qualitative study could utilize focus-group discussions and interviews with school leaders, teachers, and students to delve deeper into teacher efficacy, student self-efficacy, and multiple intelligences. Gleaning the views from school leaders can inform the system of how they feel about the integrated STEM program, school readiness, and the resources that are needed for a successful implementation of the STEM program. The literature pointed out that school leadership plays a critical role in the implementation of the STEM program. The belief that school leaders display can influence the attitudes and energies of the critical players in the school. In addition, teachers play a critical role and can be led in believing that they are valued in the successful implementation of the integrated STEM program.

This proposed qualitative study will allow teachers to record their concerns and opinions about their teacher efficacy and what they think needs to be done to enable teachers to be better equipped to deliver the integrated STEM program. In addition, students being given a chance to

express themselves freely can provide great insights into what excites them, encourages them to work harder, and how they feel about their teachers. Importantly, as we move forward into the 21st century, educational practitioners must be mindful of the learners with whom they interact. All students do not learn the same way; hence, a focus on multiple intelligences is critical. Focusing on multiple intelligences has the potential of enabling students to perform optimally in their areas of interest. The findings from this proposed study could be significant because insights from these critical groups have the potential to impact the implementation of the integrated STEM program positively. This study also has the potential to advance scientific knowledge by taking steps to understand school leaders' beliefs and concerns, teacher efficacy, student self-efficacy, and how these affect academic performance in the STEM program.

The final recommendation for future research is for the utilization of a qualitative grounded theory in which group discussions involve school board members, parents, past students, and business interests in the community. The results of this proposed study could reveal if there are deeply held stereotypes and could also get a deeper understanding of social perceptions of the STEM schools and some factors that prevent students from completing their course of study and not sitting all the CSEC examinations for which they are eligible, along with other exit exams. This proposed study will give the school boards that govern schools in Jamaica the opportunity to record their views about the implementation of the integrated STEM program, and the impact that it is likely to have, if any, in terms of improving academic performance. It is very imperative that the school board appreciates the value of the integrated STEM program. Having its members believing in the program will help with the smooth implementation. The views of parents should be a factor in the implementation of the integrated STEM program.

Parental support is critical to the success and endurance of the new program. Parents have a voice, and some are influential in what programs are implemented at their schools.

Past students also have a vested interest in their schools; therefore, to hear from them directly about the implementation of the integrated STEM program is critical. Importantly, past students also contribute financially to school operations; therefore, to guarantee their continued support, their voices must be heard. The education system ultimately produces graduates who take up jobs in the business sector. It is crucial, therefore, to hear how business interests feel about this new program and its ability to improve the quality of prospective employees. The prospective researcher can utilize this approach, which could encourage brainstorming that may result in unearthing new perspectives and that may require additional variables to be added to the study. There is no one way of doing anything, and by being involved in these discussions, the researcher is placed in a strategic position to take a second look at the variables along with the direction of the study. The proposed study can be used to advance scientific knowledge by creating additional opportunities and strategies to improve students' academic success. Policy makers could also use the findings from this study to modify the implementation of the STEM program by incorporating the views of these stakeholders.

Summary of the Study

The purpose of this quantitative causal-comparative study was to determine whether the integrated STEM program has influenced student achievement scores. This study has revealed that the integrated STEM program has impacted student achievement scores on the CSEC throughout three years. Guided by three quantitative research questions, the data from this study can be useful in addressing the issue of program offerings that presently entail in the education system and how scarce taxpayers' dollars are spent in an era of improved academic performance

(Thwaites, 2015). In addition, the results from the study may help find a resolution to the perennial underperformance of the students in the Jamaican education system (Kleinbach-Sauter et al., 2015). Finally, the findings from this study may be utilized to assist education policy makers in redesigning program offerings at all levels in the education system.

The Jamaican education system has been described as underperforming and not producing graduates of high quality (Davis, 2004; Mullings, 2012; Thwaites, 2015). Education policy makers have seen it fit to introduce programs to the education system that will have an impact on student academic performance. Therefore, policy makers can adequately support the STEM program to help improve the output from the education system by allocating more resources to carry out further training of teachers, upgrade current infrastructure, build new science and technology laboratories, and improve remuneration for teachers.

The Jamaican education system has been described as underperforming when compared with countries regionally and globally. Furthermore, the education sector gets the second-highest allocation from the country's annual budget. Therefore, it is highly expected that the country get value for money by producing graduates who can fill 21st-century jobs that require skills and not just theory as was the focus of the traditional teaching and learning approach. Further, the integrated STEM program stands as an important strategic approach to expose both teachers and students to a more exciting, innovative, and practical approach to teaching and learning. Likewise, the utilization of the STEM approach to teaching and learning will ensure a greater balance between skills and theory. At the same time, it is highly probable that with all the possibilities that abound with the utilization of the integrated STEM program, the Jamaican education system will be able to attract and maintain both teacher and student interest.

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APPENDIX A

Letter Seeking Permission to Conduct Research

1 Havendale Drive,

Kingston 19,

Jamaica.

June 4, 2018

The Permanent Secretary,

Ministry of Education Youth and Information,

2-4 National Heroes Circle,

Kingston 2.

Dear Sir:

I am a student currently enrolled at the William Howard Taft University completing a higher degree in Educational Leadership, Management and Instruction. I would be extremely grateful to be permitted to carry out a study in two high schools in Kingston – [redacted]. The study will focus on the impact of the STEM program on academic performance comparing STEM and non-STEM students. In addition, the study will examine Caribbean Secondary Examination Certificate (CSEC) results for the two schools – one STEM and one non-STEM over a, 2015 -2017.

I therefore seek permission to gain access to: three years

1. CSEC results for the two high schools over three years – 2015 to 2017.
2. The enrolment data for Grade 11 in both high schools over the three years 2015 – 2017 giving a breakdown of males and females.

Background

Jamaica operates within a global context, which dictates that it produces graduates of a certain caliber who are able to compete and be productive citizens when compared to their counterparts in other developed or developing countries. Many of Jamaica's students achieve poor results in STEM subjects such as mathematics, science, engineering and information technology. They display poor work ethic and low self-confidence. Those students who display the accepted behaviors which include good work ethic, determination and self-confidence are mostly those who are enrolled in traditional high schools.

Scarce government resources have been allocated to implement the STEM program in Jamaican high schools (Jamaica Observer, 2015). A question that a taxpayer might ask, is the STEM program having an impact on the work force or is it improving the quality of graduates who enter STEM vocations at universities. Several national organizations have displayed great interest in the implementation of the STEM program because of the poor quality of graduates who seek employment. Industry players are also of the view that jobs in STEM fields will balloon and continue to provide higher earning power for employees. There is even higher pressure on the education system to provide talented and skilled youth to fill this demand in the STEM workforce. Therefore, the education system must produce graduates who can adequately function in these jobs. However, it is not known if the time and resources devoted to the STEM program and students' self-efficacy have impacted student achievement scores.

Rationale for the Study

The main motivating factors behind investigating the impact of the STEM program in Jamaica are extrinsic. Too many of our young people are resorting to crime and other illegal activities. The education system has been characterized as not fulfilling its mandate to the country. Every

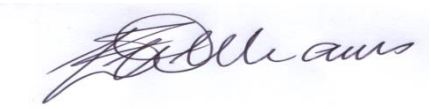
year a high percentage of tax payers' dollars goes to the education system in Jamaica. In fact, it gets the second highest allotment from the country's annual budget. The STEM program is fascinating and interesting, and as many of our students continue to struggle with the sciences and mathematics, the writer is hopeful that a new approach to how teachers deliver these subjects will help to improve performance outcomes in the STEM program. The study will examine two high schools, one stem and one non-stem of three years of CSEC exam results and conduct a comparison to determine if the STEM program has had an impact on academic performance. If proven successful, the whole aim and focus of the education system could change where all students are exposed to STEM education at the different levels of the education system.

I am confident that this study will be of benefit to the researcher and the education system at large.

I look forward to a favorable response.

God bless you as you deliberate.

Yours truly,



_____,

Ewan Williams (Mr.),

Researcher

APPENDIX B

Permission to Conduct Research

MINISTRY OF EDUCATION, YOUTH & INFORMATION

Reply or subsequent reference to this communication should be made to the Permanent Secretary and the following reference quoted:

2-4 National Heroes Circle
Kingston 4, Jamaica
Tel. 876-612-5840
Fax: 876-948-7755
www.moe.gov.jm

June 7, 2018

Mr. Ewan Williams
1 Havendale Drive
Kingston 19

Dear Mr. Williams:

Re: Permission to Conduct Research

This serves to acknowledge receipt of your correspondence requesting permission to conduct a research project to evaluate "*The Academic Performance in Jamaica, a Comparison between STEM and Non-STEM Programs*". The Ministry has approved this request on the condition that the administration of the selected schools is in agreement. Approval is also granted with the understanding that confidentiality and anonymity are maintained.

The Ministry will be notifying the administration of the institutions of its approval for the research to be conducted and henceforth you will be treating with the institutions.

Kindly acquaint yourself with the guidelines for conducting research in the Ministry's institutions which can be found at www.moey.gov.jm under "Information Resources".

We would appreciate you forwarding a copy of the findings of this survey to the Ministry of Education, Youth and Information.

Sincerely,

.....
Viviene Johnson (Mrs.)
Senior Director (Acting)
Planning and Development Division
for Permanent Secretary

COPY: Regional Director

Data Request Form

Doctoral Student: Ewan Williams

Data releasing Institution: Ministry of Education Youth and Information, Planning Department

Data requested: Caribbean Secondary Examination Certificate results for Grade 11 cohorts For [redacted] 2015-2017.

Signature: [signature]

Date: October 16, 2018

Mr. Williams,
Please note that the request has been made for the data to be provided.

for Vivienne Johnson
01/11/2018.

PLANNING & DEVELOPMENT
MINISTRY OF EDUCATION, YOUTH [redacted]
DIVISION

APPENDIX D

Descriptive Statistics

Dependent Variable: Average

gender	Schhol Type		Statistic	Bootstrap[a]			
				Bias	Std. Error	95% Confidence Interval	
						Lower	Upper
Male	STEM	Mean	38.44	-.02	.73	37.00	39.92
		Std. Deviation	12.717	-.059	.534	11.583	13.700
		N	319	0	16	289	353
	NON STEM	Mean	36.34	-.01	.81	34.80	37.89
		Std. Deviation	19.863	-.038	.446	18.972	20.700
		N	589	1	20	549	631
	Total	Mean	37.08	-.01	.58	36.00	38.13
		Std. Deviation	17.706	-.031	.368	16.970	18.402
		N	908	1	22	865	956
Female	STEM	Mean	46.75	.02	.75	45.31	48.26
		Std. Deviation	13.988	-.073	.646	12.635	15.244
		N	365	0	17	330	399
	NON STEM	Mean	37.19	.00	.89	35.53	38.96
		Std. Deviation	20.998	-.023	.473	20.003	21.924
		N	575	-1	20	534	613
	Total	Mean	40.90	.01	.65	39.65	42.15
		Std. Deviation	19.160	-.024	.414	18.348	19.985
		N	940	-1	22	892	983
Total	STEM	Mean	42.88	.00	.56	41.78	43.96
		Std. Deviation	14.028	-.044	.417	13.149	14.813
		N	684	0	20	644	723
	NON STEM	Mean	36.76	.00	.60	35.64	37.97
		Std. Deviation	20.427	-.020	.321	19.747	21.014
		N	1164	0	20	1125	1204
	Total	Mean	39.02	.00	.44	38.18	39.91
		Std. Deviation	18.554	-.020	.270	17.989	19.094
		N	1848	0	0	1848	1848

APPENDIX E

Tests of Between-Subjects Effects

Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

Dependent Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	28096.659[a]	3	9365.553	28.418	.000
Intercept	2705319.207	1	2705319.207	8208.762	.000
gender	9008.269	1	9008.269	27.334	.000
SchholType	14627.074	1	14627.074	44.383	.000
gender * SchholType	5974.692	1	5974.692	18.129	.000
Error	607717.518	1844	329.565		
Total	3449665.000	1848			
Corrected Total	635814.177	1847			

a. R Squared = .044 (Adjusted R Squared = .043)

APPENDIX F

Gender * School Type

Dependent Variable: Average

gender	Schhol Type	Mean	Std. Error	95% Confidence Interval		Bootstrap for Mean[a]			
				Lower Bound	Upper Bound	Bias	Std. Error	95% Confidence Interval	
								Lower	Upper
Male	STEM	38.442	1.016	36.449	40.435	-.016	.732	37.000	39.915
	NON STEM	36.336	.748	34.869	37.803	-.007	.813	34.803	37.885
Female	STEM	46.751	.950	44.887	48.614	.017	.754	45.308	48.264
	NON STEM	37.186	.757	35.701	38.671	-.001	.887	35.535	38.960

a. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples