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The Effects of an Elementary STEM Intervention on Fourth-Grade Outcomes in Language Arts and Math

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Abstract

The purpose of the study was to examine if a relationship existed between two schools with regard to science, technology, engineering, and math (STEM) and the growth scores from the Northwest Evaluation Assessment (NWEA). The research questions that guided this study were: (a) To what extent, if any, will students that have STEM intervention one day per week demonstrate increased NWEA English language scores on state tests?, and (b) To what extent, if any, will students that have STEM intervention one day per week demonstrate increased NWEA mathematics scores on state tests? Kinesthetic learning was used to develop an understanding of how students learn in STEM. A convenience sample was chosen for the study due to the accessibility of the population and the similarity of experimental group and the control group (Gall, Gall, & Borg, 2010). The convenience sample for the study was selected using an initial sample population of 260 fourth-grade students in School A (experimental group) and School B (control group) within the Mid-Atlantic District. The assessment used in the study to determine evidence of growth scores was the NWEA. The assessment results were compared from September 2016 to June 2017 in both reading and mathematics to determine if there was a relationship between the test scores from School A and School B based on whether the schools maintained a STEM intervention or not. A paired sample t-test was used to compare School A and School B to determine whether the scores show a significant difference when compared, and the results showed no significance in the scores. The results deliver telling information on whether or not a STEM intervention makes a difference on Grade 4 growth scores on the NWEA.

Keywords: science, technology, engineering, and mathematics (STEM), Northwest Evaluation Assessment (NWEA), kinesthetic learning, elementary science program (ESP)

Dedication

I would like to dedicate this work to my very supportive wife, Christy, without whom I could never have accomplished this seemingly daunting program. You encourage me to stand up for what is right and never give up. You are my rock and I love you. To my children, Grace and Grant, I hope you see that whatever you set your mind to, you can accomplish. All of this hard work was for you and our future. Grace and Grant, I love you more than words can say. Mommy is finally done! Finally, I would like to thank my mother, Sharon, and my sister, Holly, who always believed I could do great things. Thank you, Mom, for always being supportive and teaching me from a young age that education is valuable. And to my sister, you are a true role model for everyone. No matter what, you rise above your challenges and keep smiling. You inspire us all to be better.

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Chapter 1: Introduction

Introduction to the Problem

The demand for science, technology, engineering, and mathematics (STEM) is on the rise. The rise in careers in science and technology fields in the United States has grown over the past decade but falls behind the increased growth of European and Asian global competitors in countries that are established (National Science Board [NSB], 2010). Over the past decades, the U.S. government has provided funding for many scientific innovations. However, over time the interest in science has declined and jobs have been lost to other countries. As a result, the U.S. government began to change the educational system to achieve higher standards in STEM, with the goal to prepare students at an early age for careers in STEM. STEM education is critical to the Nation's roles and responsibilities in the world, including our ability to play a role in international development (U.S Advisors on Science and Technology, 2010).

In an effort to increase STEM performance, schools must hold students accountable to achieve higher standards in STEM. One way to demonstrate performance growth in STEM is to provide students with hands-on learning and assessments. The more students get excited about STEM, the more their passion is ignited to seek a career in a STEM field. STEM provides students with a base to build upon as they progress through school. By capturing students' interest in STEM content at an early age, the proactive approach prepares students, ensuring they can progress through middle and high school to complete the needed courses for proper preparation to enter STEM degree programs at institutions of higher learning (DeJarnette, 2012).

Background, Context, History, and Conceptual Framework for the Problem

The 20th century focused on the relationship between STEM education and national prosperity and power and by century's end, the U.S. was gaining military and economic advances made possible by STEM developments education (Burrows, Lockwood, Borowczak, Janak, & Barber, 2018). As the STEM movement grew throughout the 20th Century, it became influenced by researchers gaining traction in STEM due to their concern about world- views (Reason & Bradbury, 2001). In 2009, the U.S. Common Core Standards were developed and focused on mathematics and language arts. This STEM history and research informs work in traditional classroom settings, as well as informal learning settings such as clubs and after school activities thus supporting K–12 classrooms. STEM literacy and STEM expertise should be considered critical human capital for the 21st century economy (Burrows et al., 2018).

In today's technological and global society, STEM disciplines are seen as a cornerstone of the nation's economic growth (Gamse, Martinez, & Bozzi, 2015). By increasing students' competency in STEM fields, such education works to develop STEM-literate citizens. According to the U.S. Council of Advisors on Science and Technology (2010), STEM education has been proved to make a positive impact on the world; however, the educational system has not implemented STEM efficiently. STEM education can link scientific inquiry, by creating questions answered through investigation (Kennedy & Odell, 2014). Improving STEM education may increase the literacy of all people across the country in technology and science (NAE & NRC, 2009). As the USA and other countries work to build their capacity in STEM education, it is imperative that they interact with each other in order to enhance their efforts in international scientific engagement and building to provide quality education to all populations (Clark, 2014).

Statement of Problem

Time spent on science instruction in Grades 1–4 has decreased from an average of 3.0 hours per week in 1993–1994 (180 minutes) to 2.6 hours (156 minutes) in 2000 and 2.3 hours

(138 minutes) from 2004–2008 (Blank, 2013). This trend shows less time was spent on science in elementary classrooms as the years progressed. In many schools, the time devoted to academic subjects relates directly due to federal and state policies, state and local standards, district funding and priorities, school leadership, and teacher instructional decisions (Blank, 2013). Regardless, evidence has shown that students who acquire STEM knowledge in elementary school have significantly better scores than those with less knowledge of STEM. Even though the time in instruction has improved, there is still a division between students from low-income families. Since not all students have the opportunity to receive STEM instruction, this study sought to explore whether having a STEM intervention in elementary school would correlate with growth as measured by the Northwest Evaluation Assessment (NWEA). The NWEA is an evaluation used to assess growth scores in English Language Arts and Math.

Purpose of the Study

The purpose of the quantitative study was to determine if Grade 4 students exposed to a STEM intervention would outscore the control group counterparts on state standardized assessments (i.e., the NWEA). School A (experimental intervention group) was exposed to STEM intervention for 40 minutes over 36 weeks, and then compared to students in School B (control group) not exposed to STEM intervention in the same district to see if NWEA scores would be higher based on exposure to the STEM intervention. By assessing whether schools achieved increased performance on standardized tests, the research aimed to identify if STEM is an effective instructional intervention to implement in future school years.

Research Questions

The present study utilized the following research questions in order to determine if a STEM intervention demonstrated increased NWEA scores in English Language Arts and Mathematics.

RQ1. To what extent, if any, will students who have a STEM intervention one day per week demonstrate increased NWEA English language scores on state tests?

RQ2. To what extent, if any, will students who have a STEM intervention one day per week demonstrate increased NWEA mathematics scores on state tests?

Hypotheses

$H_1$0. There is no significant increase in NWEA English Language scores among students that attend STEM intervention once per week from September to June.

$H_1$1 There is a significant increase in NWEA English Language scores among students that attend STEM intervention once per week from September to June.

$H_2$0. There is no significant increase in NWEA Mathematics scores among students that attend STEM intervention once per week from September to June.

$H_2$1. There is a significant increase in NWEA Mathematics scores among students that attend STEM intervention once per week from September to June.

Rationale, Relevance, and Significance of the Study

The framework for the study was based on theories of four different types of learning, all of which demonstrate how students learn in STEM. First, Tolman and Honzik (1930) examined learning through reinforced behaviors in rats. Two groups were compared and the group of rats that had food reinforcement consistently did better. This type of learning is prevalent in STEM because of the hands-on learning and reinforcement of skills that are learned. Observational learning also plays an important role in STEM because students learn not only from the instructor, but also from their peers. Bandura (1977) believed that people are interactive processors and think about the connection between their behavior and its consequences (McLeod, 2016). Bandura (1977) used the Bobo doll, a toy that gets up by itself when knocked down, showed how children could emulate behavior. This type of learning is also seen in STEM in students who are motivated to learn and, therefore, pass on their interests and motivation to other students through modeling.

Second, Bruner's (1966) constructivist theory explains student learning through prior experiences and real-world reflections. Education in STEM enables students with an opportunity to think outside of the box and use hands-on learning to solve a problem. Bruner (1966) stated there are four major aspects to learning: (a) predisposition, (b) structured, (c) sequential, and (d) reward and punishment. Lave and Wenger (1991) explained how situated learning is applied to technology, showing a direct correlation to STEM.

Third, Gardner (1993) developed kinesthetic learning theory, which relates to visual, auditory, and kinesthetic learning. Education in STEM utilizes this type of learning by providing a hands-on approach to problem solving. Gardner (1993) identified stages that a person passes through as they grow into adulthood. Each one of these stages presents itself with a way of learning that incorporates STEM as students progress through school. Gardner's (1993) seven intelligences include verbal-linguistic, logical-mathematical, visual-spatial, body-kinesthetic, musical-rhythmic, interpersonal, and intrapersonal. In STEM, students target all of these aspects as they progress through school.

Finally, Piaget's (1952) cognitive learning theory provided a learning model in which students' self-question, recall, and self-assess. Piaget believed each child is born equipped with a framework that enables them to follow fundamental learning skills such as differentiation from objects, representation of words, logical thinking, and hypothesis testing. Education in STEM involves all of these frameworks. Through STEM, students utilize a diverse range of skills, motivation, and hands-on learning to develop ways to solve situational issues within society.

Definitions of Terms

Active learning: involves making physical manipulations without adding new knowledge (Auerback, Higgins, Brickman, & Andrews, 2018).

Authentic learning: A high level of learning, according to Bloom's taxonomy, by using the same tools and methods as experts use in the real world (Hoge, 2013).

Board of Cooperative Educational Services (BOCES): A group of science educators that collaborated and developed STEM interventions based on the New York State Science Learning Standards (Bocesforscience.org, 2018).

Career Technical Education (CTE): A set of course options for students to earn certification in trade careers (Lockard & Wolf, 2012).

Cross-curricular instruction: An approach to a topic that includes contributions from several different disciplines and viewpoints (Johnson, 2013).

Elementary science program (ESP): A supplemental unit that corresponds with traditional learning involving read-aloud and mathematical learning (espsciencetime.org).

Intervention: A program designed and implemented to provide students with hands-on, real-world problem-solving skills and to develop critical thinking and creativity that prepares them for the future (Roehrig, Moore, Wang, & Park, 2012).

Kinesthetic learning: A framework of learning that students with the opportunity to work together in groups and develop social skills (Gamse et al., 2015).

Measures of Academic Progress (MAP): A computer-adaptive assessment administered to students throughout the year used nationwide (nwea.org, 2015).

National STEM Foundationn (NSF): A nonprofit organization that supports and promotes STEM education (Guzey, Harwell, & Moore, 2014).

Northwest Evaluation Assessment (NWEA): A set of measures of academic progress (MAP) that determine students' growth and performance to inform classroom instruction.

President's Council of Advisors on Science and Technology (PCAST): A council chartered in each administration to advise the President on science and technology (PCAST, 2010).

Problem-based learning: An instructional learner-centered approach that empowers learners to conduct research, integrate theory and practice, and apply knowledge and skills to develop a solution to the problem.

Program for International Assessment (PISA): An international assessment given every 3 years to students age 15, which assesses skills in math, science and literacy (Desilver, 2017).

Science, technology, engineering, and mathematics (STEM): A standards-based, meta-discipline at the school level where all teachers, especially STEM teachers, utilize an integrated approach to teaching and learning where the curriculum content is not divided, but addressed and treated as one dynamic, fluid study (Brown, 2012).

Assumptions, Delimitations, and Limitations

The primary assumption in the study was that students in Grade 4 who received STEM intervention once a week for 40 minutes would score better on the NWEA versus a similar school in the district that did not have STEM intervention embedded into their curriculum. It was assumed that all students that took the NWEA did their best on the test. The STEM instructors were expected to be highly effective and qualified teachers who delivered the intervention with rigor. It was also assumed that students would not partake in any other science intervention during this time. Finally, it was assumed that students would attend and participate in the entire intervention.

One of many delimitations of this study was that it focused only on one grade level in two schools. Even though each school must teach science, the way the intervention was disseminated, and the materials used were very different. The demographics of School A were 45% Caucasian, 34% Hispanic, 14% African American, and 7% other (Mid-Atlantic District, 2017). The demographics of School B were 54% Caucasian, 29% Hispanic, 8% African American, and 9% other (Mid-Atlantic District, 2017). The two schools had similar Grade 4 state assessment scores. Math scores for both schools range from 44%–50% and English Language Arts ranged from 23%–26% (Mid-Atlantic District, 2017). This suggested a very broad and varied instructional means of delivery. Another important delimitation was finding research linked to elementary STEM. Blank (2013) linked science instructional time to achievement, while Becker and Park (2011) researched the need for STEM in schools to boost STEM careers.

One limitation of the study concerned the demographics of the school. Each town in the Mid-Atlantic District represented a diverse population. The demographics, however, did not represent the full diversity of the United States. A larger study could have achieved different results by expanding the geographical area of study to include more diverse populations. Current policies focus on school accountability and have raised the importance of instructional time and emphasis on reading and mathematics, particularly in schools and states with high rates of students from low-income families (Blank, 2013). However, in this study socioeconomic status was not factored into the study. Another limitation was Grade 4 students only had 40 minutes per week with a STEM instructor, who utilized STEM intervention developed in New York State.

Chapter Summary

In education, STEM remains a hot topic. With each year that passes, new federal and state regulations are implemented in schools. In 2018, the Next Generation Science Standards will be implemented to provide schools with the necessary tools to instruct students in STEM. Programs in STEM continue to grow and change along with the assessments used to measure student achievement. Teachers and administrators may benefit from this research as they continue to improve STEM intervention. Jobs in STEM are projected to grow by 13% from 2012–2022, creating 1 million new STEM jobs (Public Impact, 2014). At the same time, a 2013 survey of Fortune 1000 company recruiters found that only 50% could find job candidates with STEM bachelor's degrees, and 47% said this shortage limits business growth (Public Impact, 2014). This shows the importance of STEM intervention. It is important to take bold steps in STEM education to avoid losing ground as other nations grow STEM jobs (Atkinson & Mayo, 2010). It is time for new approaches based on driving innovation in STEM education that outlines specific STEM challenges in America (Atkinson & Mayo, 2010). The one size fits all approach to STEM also comes with various limitations. The Some STEM for all approach would offer students the best STEM education money can buy, however this can be costly (Atkinson & Mayo, 2010). Motivation is also a factor in some STEM for all approach because all active learners have different desires (Atkinson & Mayo, 2010). Over 80% of STEM jobs are in engineering and information technology yet engineering and computer science are lacking in high schools. A necessary step for reform is to allow student access to a wide variety of STEM disciplines (Atkinson & Mayo, 2010). It appears that over the last decades our educational system has been solely to prepare students for standardized test versus teaching them how to use knowledge they have learned (Moye, Dugger, & Stark-Weather, 2014).

Chapter 2: Literature Review

The majority of American students are neither prepared nor sufficiently engaged to become STEM-literate citizens or innovative STEM professionals (National Research Council [NRC], 2007; NSB, 2010; President's Council of Advisors on Science and Technology [PCAST], 2010). Research has shown a decrease in preparation in STEM fields. In response, the U.S. government prioritized creating leaders in the field of technology. The United States was an early world leader in scientific innovation in the early 1950s and 1960s. However, as time progressed, the U.S. government decreased funding in American innovation. The U.S. federal share was 70% throughout the 1960s and 1970s and stood at 61% in 2004 before falling below 50% in 2013 (Mervis, 2017). At the same time, other countries have excelled in providing the STEM training and preparation once dominated by the United States. In 2007, the United States scored behind Taiwan, Singapore, Japan, and Hong Kong on a Grade 4 mathematics exam in the Trends in International Mathematics and Science Study (Epstein & Miller, 2011). Grade 4 students also scored below students from Asia, England, Russia, and the Czech Republic in math (Epstein & Miller, 2011). Research has further shown a large share of U.S. science degrees are awarded to people born abroad (Borjas, 2005), and since 1990, America's dependence on foreign-born and foreign-trained scientists has increased (Xie & Achen, 2009). As a result, some Americans have felt they are losing competitive innovation and engineering to other countries.

For the United States to stay globally competitive in STEM, well-qualified teachers and STEM curricula must increase in K–12 education (Avery & Reeve, 2013). The educational system must therefore change and elicit performance indicators for STEM. Efforts to reevaluate and improve elementary science over the past 20 years have occurred during the era of K–12 education reform and been highlighted by national and state standards that have raised the importance of assessments and accountability (Blank, 2013). In a recent example, in an effort to increase the growth of students in STEM, a Mid-Atlantic District created a STEM intervention for elementary students in 2016. The goal of this intervention was to ignite students' love of STEM through experiments and blended teaching of math and English language arts and increase students' academic scores. Innovative methods were developed that coincided with the state standards and assisted students in preparing for the NWEA.

Education in STEM has been driven by global initiatives and economic growth. Educators must provide students with multicultural viewpoints demonstrating a global perspective that connects students with STEM communities (Kennedy & Odell, 2014). By providing such hands-on education, STEM experiences help students to prepare for global challenges and the many complexities in the world (Friedman, 2005), while breaking down each subject and making connections to the context of the real world (Chiu, Price, & Ovrahim, 2015). Students exposed to integrative learning demonstrate higher levels of achievement and leadership in STEM (Becker & Park, 2011). Basing STEM learning in real-world problems can help more girls in the classroom (Sjoberg & Schreiner, 2010). Some real-world problems include climate change, disease eradication, medicine and solving food shortages (Filippi & Agarwal, 2017).

However, many challenges arise in integrating STEM intervention in education. Winn, Choi, & Hand (2016) noted that little research is available on elementary school STEM education. Time on task, lack of professional development, and inadequate supplies hinder many STEM. However, educators are prepared to meet these challenges by integrating STEM into current standards of learning. Teachers play the role of "designers" in STEM education.

Teachers can design their own classrooms as a place of inquiry and find similar interests at school and in the community to sustain the passion for teaching STEM (Filippi & Agarwal, 2017). Dramatically reshaping schools to allow for greater opportunity in a wide variety of STEM subject will shift how STEM is viewed. According to Atkinson, & Mayo (2010), There are three ways schools can shift how STEM is viewed. First, schools can offer more STEM related courses in K–12. Second, shifting accountability from content-based to skills-based assessments. Lastly, the Department of Education would ensure the creating of 400 new specialty STEM schools in the country.

Conceptual Framework

The framework for this research was based on four types of learning that together show how students learn in STEM: observational learning, constructivist theory, kinesthetic learning, and cognitivist learning. First, Tolman and Honzik (1930) conducted an experiment comparing providing an example of observational learning whereby lab rats fed within a maze setting with food reinforcement versus rats that were led through the maze without food reinforcement (Ciancia, 1991). As the rats continued to run the maze, both groups quickly decreased their time in the maze. Rats in the non-reinforced group learned alternative features of the maze and, therefore, when food was added, time decreased substantially. Such performance was displayed through learned skills. In an educational context, observational learning proposes retention of new information can be achieved by observing others who are engaged in a task. By observing teachers and peers, students obtain new knowledge they did not possess at the time they learned the skill.

Bandura believed that people are interactive thinkers and focus on relationships between their behavior and its consequences (McLeod, 2016). Observational learning helps children gain new answers by observing others. In 1961, Bandura conducted the Bobo doll experiment to demonstrate observational learning. Adults demonstrated aggression with the doll and, when left alone, the children replicated the same aggression. Students that are more interested in a skill are more motivated to learn and enhance their knowledge in that skill area (Artino, 2007). Education in STEM provides an opportunity for students to utilize modeled behavior to acquire a new skill.

The constructivist theory is also based on observation and explains how students learn. Schunk (2004) considered constructivism as epistemology by focusing on the nature of knowledge individuals obtain through understanding, self-construction, and real-world experience. However, the construction of knowledge and engaging students with hands-on activities is important for learning but may not be sufficient (Dewey, 1963). Dewey discovered there is a strong connection between education and educational experiences. Based upon the work of Dewey, American theorist Kolb believes learning to be a process where knowledge is created through transformational experiences (Kolb, 1984).

Students develop their own understanding and knowledge through prior experiences and real-world reflections. Education in STEM provides students with the opportunity to be hands-on and use their prior knowledge to think outside of the box to solve a problem. Bruner (1966) stated that the theory of instruction should be composed of four major aspects: (a) predisposition towards learning, (b) the way knowledge can be viewed so the learner can understand, (c) the most effective way to present the material, and (d) the nature and pacing of rewards and punishments. Good methods for structuring knowledge should result in simplifying, promoting new ideas, and increasing the manipulation of information (Culatta, 2016). Education in STEM provides students with the experience of active learning based on current or past knowledge. It utilizes a constructivist approach based on how students learn and draws upon the formation of new skills from prior knowledge. The constructivist approach is also evident in authentic learning. Authentic learning is learning at increased levels of Bloom's taxonomy via same tools and methods as experts in the real world. Authentic learning involves inquiry and problem solving (Hoge, 2013). This type of learning is fundamental to philosophy of constructivism and has been shown to be the best way to teach STEM content and skills (Slough, Aoki, Hoge, & Spears, 2004).

When students are motivated to learn, they are more likely to understand the concept being taught. Research has shown that providing STEM at an early age increases assessment scores in elementary school as well as prepares students for 21st-century careers in STEM (Chiu et al., 2015). Research has also shown that using successful female examples in STEM demonstrate girls are more likely to enter STEM careers and overcome challenges (Blickenstaff, 2005). For example, women in undergraduate engineering degrees who read biographies of female engineers had more positive attitudes toward mathematics compared to women who read biographies of male engineers (Stout et al., 2011). Girls have been proven to be more interested in science education that is based on real-world problems (Cheryan, 2012). The constructivist theory does not focus on content but on the learning itself (Hein, 2009). The theory supports the female social aspect of learning. There is a gap in STEM education within the female population. The factors contributing to the gap include negative stereotypes, lack of STEM opportunities, demographic factors and socioeconomic status (Brotman & Moore, 2008). The theory supports the process of learning rather than content. Females recognize the social aspects of learning and reinforcement of STEM participation.

Situated learning is a theory of knowledge acquisition developed by Lave and Wenger (1991). This theory had been applied to technology-based learning and problem-solving skills wherein learners become involved in real-world activities. Students apply STEM learning both inside and outside of school by taking a hands-on approach to solving problems that affect individuals every day.

The foundation of STEM incorporates problem solving and hands-on learning. Gardner (1993) developed kinesthetic learning theory, which examines human expression in relation to three main sensory learning styles: visual, auditory, and kinesthetic. Gardner (1993) found that intelligence is made up of different abilities, which originate in the stages of development each person passes through as they grow to adulthood. There are at least seven intelligences—verbal–linguistic, logical–mathematical, visual–spatial, body–kinesthetic, musical– rhythmic, interpersonal, and intrapersonal—though research suggests there may be more (Weiler, 2004). Kinesthetic learning aligns with STEM in many ways. In STEM, students use visual, hands-on, and auditory means of exploration in order to complete science-related tasks. Kinesthetic learning plays an important role in active learning. When students are active learners they participate in making physical manipulations without adding external knowledge (Auerbach, Higgins, Brickman, & Andrews, 2018). Kinesthetic learning assists students to learn at their own stage of growth. As each child learns differently, each child is given various ways to complete a science task. Within scientific learning, it is important that children develop the skills needed for investigation (Harlen, 2013). Kinesthetic learning helps children to grow at their own level over time using the seven intelligences developed by Gardner. Teachers should design environments that allow for the child to explore, play, and learn (Dejonckheere, Van de Keere, Wit, & Vervaet, 2016).

Piaget believed that children do not learn in just one way and suggested that there are certain points where their minds simply “take off” to different areas (Atherton, 2011). Piaget determined four stages of cognitive development for children from birth to 11 years and older: (a) differentiation of self from objects, (b) learning language and that objects represent words, (c) logical thinking, and (d) thinking logically and testing out hypotheses in action (Atherton, 2011). Based on Piaget’s learning model, students use these steps to help them solve problems. Students are able to self-question, recall information, and self-assess. Piaget’s theory asserts that intellectual development is a direct result of biological development. A child is born biologically equipped to make a variety of motor responses, which provide them with the framework for the thought processes that follow (Simatwa, 2010). Piaget’s theory suggests that teachers should provide a learning environment that is rich in physical experiences because growth in any one stage depends upon such activity (Simatwa, 2010).

In this study, Grade 4 students were chosen based on the rigor and availability of assessments in the Mid-Atlantic District. Students in Grade 4 demonstrate two basic objectives, according to Piaget’s stages of development: (a) the child should be able to obtain reading, writing, and arithmetic skills; and (b) the child should be able to accept his/her aptitude for school (Simatwa, 2010). Education in STEM encompasses all of Piaget’s stages of cognitive development by providing opportunities to learn how to solve real-world problems using logical thinking and differentiation. Within this research, students learned to apply STEM learning to the NWEA test. This involved being able to understand, recall, represent, and develop thinking as they progressed through the test. The NWEA assessment provides the opportunity for students to perform logical thinking on STEM-related tasks. Piaget’s framework was demonstrated through STEM and assessed within the NWEA.

With an understanding of the four types of learning discussed above, STEM is even more relevant for students. All of these learning theories require a hands-on approach and out-of-the-box thinking in an elementary setting. These learning theories help educators see STEM through a different lens that will assist students in future learning. Of the four theories, kinesthetic learning most embodies STEM and students' way of learning through hands-on, visual, and auditory learning. Most engineers are global learners and utilize all of the kinesthetic learning tools (Felder, & Silverman, 1988). Throughout STEM interventions, all of these sensory learning styles were utilized and applied as students performed tasks in the STEM lab.

Review of Research Literature and Methodological Literature

The Evolution of STEM

Historically, the United States has produced leaders in STEM such as Stephen Hawking, Tim Berners-Lee, and Ellen Stofan (Shotwell, 2010). However, Americans struggle to remain on the cutting edge of technology. The National STEM Foundation, a nonprofit organization that supports and promotes STEM education, stated the nation's technological innovation is in peril. In 1957, the United States had its first competitive taste of innovation with the launch of Sputnik by the Soviet Union. This was the first orbiting satellite the size of a beach ball. This started the space race between the United States and Soviet Union. Presidents Dwight D. Eisenhower and John F. Kennedy urged Americans to develop an interest in STEM to keep up with the growing technology of other countries. In order to increase future technology, there must be more individuals interested in the field of science (Guzey, Harwell, & Moore, 2014).

By 1958, President Eisenhower established the National Aeronautics and Space Administration (NASA), a leader in innovation and technology (Shotwell, 2010). This sparked interest in the field of STEM. Government-led initiatives subsequently allowed scientists to work together in developing engineering technologies without contributing to the Cold War between the Soviet Union and the United States. Organizations like NASA have continued to evolve and produce some of the most amazing advancements in technology (Shotwell, 2010). As time progressed, new innovation and technology emerged such as the cell phone and personal computer. The 1980s were filled with encouraging technology and an overwhelming desire for science. Yet, there were no guidelines for a science curriculum within the education system. In 1990, the National Science Education Standards and National Council of Teachers of Mathematics aimed to assist educators and prepare students for the innovative thinking required in STEM, leading to the development of the first "STEM" curriculum (Shotwell, 2010). The NRC (2007) has highlighted the need for U.S. students to increase their knowledge in STEM.

The United States has struggled to remain at the top of the STEM field. Public Impact (2014) reported only 5% of U.S. workers work in science and engineering. A 2007 report from the U.S. National Academics of Science, Engineering, and Medicine stated that U.S. proficiency in STEM training lags behind other countries and, in order to succeed and surpass other countries, students need to be better prepared in STEM disciplines (National Academics of Sciences Engineering Medicine, 2017). Therefore, in response, in 2009 President Barrack Obama announced the 10-year stem STEM initiative over the next 10 years. According to President Obama, while delivering in his 2010 State of the Union address, nations such as China, Germany, and India were not waiting to improve their economies by focusing on science and mathematics, and the United States should not wait either (McGrew, 2012). President Obama stated in his 2010 State of the Union address that nations like China and India realized that with some changes of their own, they could compete in this new world (Robelen, 2011). China and India started educating their children at an earlier age and put more time into math and science instruction. They're investing in research and new technologies. Just recently, China became the home to the world's largest private solar research facility, and the world's fastest computer. In 2011, the federal budget included 3.7 billion for STEM education programs (Parker, Denisova, & Abel, 2015).

On January 25, 2011, President Obama became the first sitting president to speak the words "science, technology, engineering, and math" in his State of the Union address:

> Let's also remember that after parents, the biggest impact on a child's success comes from the man or woman at the front of the classroom. In South Korea, teachers are known as "nation builders." Here in America, it's time we treated the people who educate our children with the same level of respect. We want to reward good teachers and stop making excuses for bad ones. And over the next 10 years, with so many baby boomers retiring from our classrooms, we want to prepare 100,000 new teachers in the fields of science and technology and engineering and math.
>
> (Obamawhitehouse.archives.gov, 2011)

Educational policymakers have subsequently paid more attention to the learning and skills necessary for STEM careers (Unfried, Faber, Stanhope, & Wiebe, 2015). PISA (Program for International Assessment) is an international assessment given every 3 years to students age 15, which assesses skills in math, science and literacy (Desilver, 2017).

In 2015, PISA ranked United States students 38th out of 71 countries in math and science. There are many factors that can attribute to the decline in STEM skills in America. Limited parental involvement, lack of student interest and motivation are just a few issues facing STEM education (Funk & Parker, 2018). There are many reasons other countries are ahead of the United States when it comes to STEM-related fields. In Asian countries, culture and mindset play a role in education. There is a high value placed on education and a belief that effort rather than innate ability is the key to success (Boylan, 2016). Asian students attend school during the day and return home to complete another two hours of tutoring along with 2 hours of homework. Another factor that contributes to higher scores is the teacher. Teaching is competitive and respected in Asian countries (Boylan, 2016). In Japan, “lesson study” is embedded in primary schools. This involves teachers planning carefully designed lessons, observing each other’s teaching, and then drawing out the learning points from these observations. Lesson study also gives teachers time to research and professionally develop together (Boylan, 2016). Jerome Bruner’s Stages of Representation is the basis Asian education. These stages focus on hands-on experience and visual representations, which is the basis for learning symbolic or linguistic formulations (Boylan, 2016).

In order to close the gap in STEM versus other countries, the United States must have a plan. By 2021, the federal government will have invested in the training and preparation of over 100,000 teachers in the STEM field (Obamawhitehouse.archives.gov, 2011). The State Education Department would use 80 million dollars from the President’s budget to improve and expand teacher preparation within STEM and update instructional materials (Mervis, 2011). The primary goal of the STEM movement is to promote a future STEM workforce and maintain the United States as a leader in innovation (Vega, 2012). There are many benefits of STEM that include ensuring students to become more self-reliant, better problem solvers as well as more technologically literate (Stohlmann, Moore, & Roehrig, 2012).

According to the United States Department of Labor on 5% of workers are employed in science and engineering fields and yet 50% of our economy is based off of these fields (Adkins, 2012). The disparity between the United States and other countries exists and we must find a way to close the gap. There are many steps the United States can take to close the gap versus other countries. Creating and maintaining an interest in STEM is the key. Increasing partnerships with companies that are STEM, such as IBM, create relationships between schools and businesses. These companies guide STEM initiative and provide industry trends to schools (Adkins, 2012). STEM-related degrees represent about a third of degrees in the United States, which is significantly different from Japan, China and Singapore that produce a one to two ratio in STEM-related degrees (Adkins, 2012). Another way to close the gap between the United States and other countries in STEM is to promote STEM to women. Women are responsible for only less than 25% of STEM jobs in this country. We need to shift our thinking and promote STEM at an early age to girls in hopes they will strive to have a career in STEM-related fields.

What is STEM?

The field of STEM is defined by the merging of the disciplines of science, technology, engineering, and mathematics in order to: (a) deepen student understanding by contextualizing concepts, (b) broaden student understanding through exposure to socially and culturally relevant STEM contexts, and (c) increase interest in STEM disciplines and expand the pathways for students to enter STEM fields (Roehrig, Moore, Wang, & Park, 2012). STEM intervention is designed and implemented to provide students with hands-on, real-world problem-solving skills and to develop critical thinking and creativity that prepares them for the future. One goal of this research was to determine if having an elementary STEM intervention would yield higher state test scores when compared to a similar school within the district that did not have an elementary STEM intervention. Data from the NWEA was used to measure the success of the STEM program as well as the New York State Assessment. The NWEA measures growth from September to June and is administered twice per year. The New York State Assessment is given in March and measures English language performance, including on questions in science. The information gained from this study provided data and results for the district, demonstrating the potential benefit of having an elementary STEM intervention in all elementary schools.

Importance of STEM

The field of STEM is important because it prepares students for future careers (Daugherty, Carter, & Swagerty, 2014). Jobs in STEM are projected to grow by 13% from 2012–2022, creating 1 million new STEM positions (Public Impact, 2014). Throughout a student’s schooling, they learn to think outside of the box and focus on real-world solutions to real-world problems. Students in STEM that participate in spontaneous exploration have opportunities for meaningful and informative reflection (Dejonckheere et al., 2016). For example, students in STEM may be given the task of building a bridge with designated items. The students must first work collaboratively and design a plan for the bridge, and then use cooperative learning strategies to help them reach their goal of building the bridge.

Each student plays an important role and everyone has to listen to each other and collaborate to accomplish the goal. Such STEM challenges are designed using the cycle of planning, checking, and sharing. In the planning stage, students analyze and write about reading related to a theme that is differentiated according to student reading levels (Molina, Borror, & Desir, 2016). During the design stage, students discuss the strengths and weaknesses of the prototype drawings, and then collectively decide on a group design (Molina et al., 2016). Final designs are then shared and discussed with the class. Collaboration makes STEM different from classroom learning based on the level of communication, design, and hands-on learning, and allows for kinesthetic learning to be utilized within the STEM lab.

A true STEM education should increase students' understanding of how things work and improve their use of technologies (Bybee, 2010). Such activities demonstrate how science, math, and technology can be blended and adapted to real-world experiences. National surveys of elementary school teachers have revealed 99% of teachers report mathematics is done every day, while 24% of teachers report science is done every day (Madden, Beyers, & O'Brien, 2016). This disparity demonstrates the lack of attention given to STEM. In elementary schools, STEM gives children an entry-level degree of awareness and preparedness for upper-grades in STEM. To promote STEM majors, schools must catch students at a young age and get them excited about technology (Vaidyanathan, 2012).

As students' progress to middle school and beyond, learning becomes more rigorous and challenging in STEM. Middle school is where students begin to develop those skills needed for a future within the STEM disciplines. Middle school is a crucial intervention point for encouraging students to pursue engineering (Billiar, Hubelbank, Olivia, & Camesano, 2014). Students have reported that math becomes more difficult, they receive less help from teachers and parents, and they become more anxious about technical material in the middle school years (Adelman, 1998). In high school, the program of study shifts to focus on the application of the subjects in a challenging and rigorous manner. A decrease in frequency of technology and engineering instruction results from the demands of high-stakes testing that forces teachers to spend more time on core subjects such as reading, writing, and math (Daugherty et al., 2014). Emphasis should be placed on bridging in-school and out-of-school STEM opportunities in order to develop the thinking needed for the 21st century (Rincon & George-Jackson, 2016).

New skills and demands in the workplace require STEM skills (Epstein & Miller, 2011). However, shortages of high-skilled workers in related areas continued to be reported (SETDA, 2008). Research has suggested that without STEM literacy, students are not armed to succeed in the jobs of the future (Kesidou & Koppal, 2004). Today, many states and school districts include some form of STEM embedded in the curriculum. According to the literature, high-quality STEM education should include challenging mathematics and science curriculum and instruction STEM should also promote engineering design and problem solving as a way to develop a practical understanding of the world (Kennedy & Odell, 2014). By promoting inquiry as a way to develop a deep understanding of nature and the designed world students gain an alternative way of thinking (National Science Teachers Association, 2004). Developing grade level material that encompasses hands-on and collaborative approaches to learning promote STEM. Student outcomes should reflect the most current information and knowledge in the STEM field (Kennedy & Odell, 2014). By using appropriate technology such as modeling, active learning and distance learning STEM experiences and investigations are strengthened.

For several years, politicians and educational leaders worked to strengthen STEM education in the United States with the aim, according to the National Governors Association, to "increase the proficiency of all students in STEM and grow the number of students who pursue STEM careers" (Daugherty et al., 2014, p. 47). The reasons are clear and compelling: "STEM occupations are among the highest paying, fastest growing, and most influential in driving economic growth and innovation" (Daugherty et al., 2014, p. 47).

STEM Intervention

The educational resource BOCES 4 Science STEM Kits is a collaboration between four New York State Board of Cooperative Educational Services (BOCES). Science educators collaborated to respond to the need for instructional interventions based on the New York State Science Learning Standards. A framework for K–12 Science Education provided the basis for the Science Learning Standards and the Boces 4 Science STEM Kits (Boces4Science.org, 2018). Within the 40-minute intervention, students are exposed to 15 science instructional sessions in each unit of study. The units span a 36-week period with each lesson carrying over to the next week if necessary. The intervention also includes a Student Science Journal for students to complete over the period of instruction. The Boces 4 Science STEM intervention includes at least one element from each of the three dimensions identified in the New York State Science Learning Standards (Boces4Science.org, 2018).

Bassage (2016) listed the components provided in lessons of the Boces 4 Science STEM intervention unit kits provide lessons that demonstrate include the following:

- Explaining Phenomena or Designing Solutions to Problems: The unit focuses on supporting students.
- Three Dimensions: The unit helps students develop and use multiple grade-appropriate elements of the standards, which are selected to make sense of the design solution to the problem.
- Integrating the Three Dimensions for Instruction and Assessment: The unit elicits student artifacts that show direct, observable evidence of three-dimensional learning.
- Relevance and Authenticity: By taking advantage of student questions and experiences in the context of their homes, neighborhood, and community, the lessons in the unit motivate student sense-making or problem solving.
- Student Ideas: The unit provides opportunities for students to express clarify, justify, interpret, or represent their ideas and to respond to peer and teacher feedback.

- Building on Students' Prior Knowledge: Since student understanding grows over time, this unit identifies and builds on students' prior learning in the three dimensions in such a way as it is explicit to both students and teachers. (Bassage, 2016, p. 6)

Each lesson begins with extensive vocabulary work, background knowledge of the subject, procedure, phenomenon, and lesson closing. Connections to cross-discipline areas are provided at the end of each unit for teachers to review in the classroom during general studies (Bassage, 2016). STEM interventions can be demonstrated through problem-based learning. Problem-based learning prepares students with real-world situational problems while promoting empowerment to the learners in order for the learner to develop a viable solution to the problem (Savery, 2006). The integration into a STEM intervention via problem-based learning helps the student with critical thinking, analyzing, solving problems and collaborative communication. In a problem-based STEM intervention the problem simulation must be structured for free inquiry. The learning must be integrated amongst other curriculum disciplines and collaboration is essential (Savery, 2006). Students must be able to reflect upon what was learned and apply the learning back to the problem with a solution.

Time on Instruction

A valuable resource in schools is time. As schools change and grow, teachers are expected to cover all of the core subjects in the allotted instructional time of their workday. Despite the change in instructional expectations and growing standards, the amount of time available to teachers has not changed (Brown, 2016). Every teacher has the same 24 hours in each day, of which typically 6 hours are allocated for instruction (Brown, 2016). A report by the National Reading Panel (NRP, 2000) summarized available research about reading instruction and documented that teachers must cover five key aspects of reading at all grade levels: (a) phonemic awareness, (b) phonics, (c) fluency, (d) vocabulary, and (e) comprehension (Brown, 2016). The NRP did not specify, however, how much time is needed for this instruction. The Florida Center for Reading Research further examined research on reading instruction and concluded that in the elementary grades, a total of 90 minutes per day is recommended (as cited in Brown, 2016). However, little research has determined how much time to spend on other subjects. Therefore, effective teaching practices balance subjects by developing a pacing schedule that allocates time for students to participate in daily core instruction as well as other academic areas (Brown, 2016).

Elementary Science Program Intervention

The Elementary Science Program (ESP) is a correlation guide used for science interventions within the classroom. It supports the New York State Common Core Standards in English language arts and mathematics. The ESP was established by the Monroe 2-Orleans BOCES in 1972 to provide science materials and in-service training for elementary science teachers (espsciencetime.org, 2018). Within the ESP kits, the topics directly correlate to the New York Common Core Learning Standards in English language arts and literacy in history/social studies, science and technical subjects, and the New York State Common Core Learning Standards in Mathematics (espsciencetime.org, 2018). The units of study include: (a) astronomy, (b) buoyancy, (c) butterflies, (d) classroom plants, (e) crayfish, and (f) electrical circuits (espsciencetime.org, 2018).

In terms of implementation of the ESP, students have an activity book/journal to make predictions based on the subject of instruction. Once they make the predictions, the students complete the experiment and answer questions based on their results. There are 10 activities within each unit of study. Each student performs the experiment and records the results of the experiment in their journals. During the 40-minute ESP intervention, students also complete worksheets based on the unit of study. Toward the end of the lesson, the instructor does not provide cross-curricular material to complete in class (espsciencetime.org, 2018).

Teaching and Learning Challenges

When looking at challenges there is the lack of direction and implementation of STEM within elementary schools. The development of an effective STEM intervention must incorporate key factors including: (a) professional development literature, (b) science and math professional development research, and (c) engineering and technology professional development research (Avery & Reeve, 2013). Education in STEM represents such broad fields of study that it makes it challenging to devote enough time to STEM during the school day. There are many teaching challenges as well. Lack of teacher training in the STEM field and no adopted STEM standards make teaching elementary STEM difficult (Daugherty et al., 2014). Teacher participation in STEM professional development may provide opportunities to create community partnerships with business and industry leaders (McLaughlin, 2009). One reason the education system has not produced a high number of STEM graduates is that schools tend to teach tasks in isolation from industry (Atkinson & Mayo, 2010). Offering school incentives for teachers tend to bring best practices and a new way of recruiting talented STEM educators. Without proper training and professional development, it is difficult to implement STEM at the elementary level.

Additionally, historically the primary focus of STEM had been strictly in high schools (Epstein & Miller, 2011). Education in STEM should begin in elementary schools and bridge the gap between middle and high school. When students become curious about STEM at an early age, it transcends into the secondary fields (Anderson, 2014). Given the harsh structure of the curricula in elementary schools, which is typically compartmentalized into the core academic subjects of mathematics, science, language arts, and social studies—there is little room for subjects such as technology and engineering, which targets all students (Epstein & Miller, 2011). The challenges become easier when students move onto middle and high school and are able to select and tailor their education. As such, academic transformation in K–12 schools is necessary to provide high-quality, effective STEM instruction (Trust, 2014).

In the United States, school-based factors that positively influence the success of traditionally underrepresented students in K–12 STEM education include parental involvement and support, availability of bilingual education, culturally relevant pedagogy, early exposure to STEM fields, interest in STEM careers, self-efficacy in STEM subjects, and STEM-related educational opportunities and support programs (Museus, Palmer, Davis, & Maramba, 2011). Students who use technology tend to: (a) spend more time involved in collaborative work, (b) participate in more project-based instruction, (c) produce writing of higher quality and greater length, (d) gain increased access to information, (e) improve research analysis skills, and (f) spend more time doing homework digitally. Research has also shown that using technology at the beginning of class sessions helps students to stay on task and concentrate (Spires, Lee, Turner, & Johnson, 2008).

Another issue related to elementary STEM education is the lack of technology at the elementary level. When students use technology in schools and discover concepts of technology, it prepares them for more STEM learning. Technology investment is crucial for STEM to be implemented successfully in elementary curricula (Yoon, Dyehouse, Lucietto, Diefes-Dux, & Capobianco, 2014). However, as technology is always evolving, it is difficult for schools to remain up to date. Once a school purchases technology, it may find itself in need of newer technology within a couple of years.

Review of Methodological Issues

In research, examinations of pedagogical knowledge have linked student outcomes in a STEM education environment versus a non-STEM education environment in similar schools in a district. Student outcomes may include: (a) increased English language scores on state tests, (b) increased mathematics scores on state tests, and/or (c) increased scores in writing in the science field. Pedagogical choices made by teachers in planning may assist with increased scores (Hudson, English, Dawes, King, & Baker, 2015). The specific grade level and type of assessment used to provide growth and achievement varies within the research. However, there is little information about STEM education and outcomes at the elementary level. Future studies are thus needed that target early age groups with specific learning measures.

Within the literature, researchers have utilized various methodologies to acquire data and information concerning STEM and student performance. This section outlines the methodologies used and strengths and weaknesses of each method. The primary challenge encountered in reviewing the research was the lack of research tailored to elementary grades. For many elementary educators, STEM is an up and coming topic. In contrast, there is a lot of information on the effects of STEM in high school, as the majority of studies have focused on professional development and higher learning.

Yoon et al. (2014) used pre- and posttests to analyze data using classical test theory by comparing a control group to a non-controlled group in STEM. The authors performed ANCOVA to analyze the validity of evidence for students who took pretests and posttests in STEM. Yoon et al. (2014) also analyzed the male and female groups using a two-way

ANCOVA. The data showed an increase from the pre- and posttests in males and females with regard to STEM instruction. The statistical analysis proved STEM was valid among the pre- and posttest groups. This study demonstrated the use of a statistical model that was accurate and informative. Yoon et al. (2014) revealed the increased effect of STEM education on ethnically diverse elementary students' content knowledge and perceptions of engineering regardless of gender. Significant changes with regards to knowledge and aspirations are strong predictors of the potential impact of STEM integration.

Harwell, Moreno, and Phillips (2015) used an item analysis and pilot assessment to prove proficiency amongst students. The Rasch IRT model characterized relationships between student proficiency and response (Guzey et al., 2014). Winsteps software was used to demonstrate how well the model exemplified the data. The data provided information regarding discrepancies. The results showed STEM-oriented instruction proved to be valid. Using the Rasch IRT model highlighted discrepancies from the pilot assessment.

One particular study of STEM assessments on elementary and middle school students provided the best comparison to the present research. The purpose of the study was to develop accurate assessments that would determine student growth in Grades 4–8 in STEM. Harwell et al. (2015) used the six steps in Bloom's taxonomy to understand how students learn. Teachers were placed in a cohort to develop a STEM-integrated curriculum. The assessment used in determining student growth was the Measures of Academic Progress test (MAP). The MAP program involves two components: (a) computer-adaptive assessments administered to students throughout the year, and (b) teacher training and access to MAP resources on how to use data from these assessments to differentiate instruction. The MAP program is currently used in over 20% of school districts nationwide (http://www.nwea.org/support/article/1339). Harwell et al.

(2015) conducted an item analysis to determine if the classroom environment affected performance as well as classroom size and student absence. The main methodological gap identified in the study was that the MAP test did not cover the engineering portion of the STEM process. The study suggested the MAP test was limited in providing full STEM-integrated student growth scores. This study was closely related to the present research, which utilized the NWEA (also a MAP) to assess Grade 4 student growth in STEM. Future research requires assessments that can directly relate to integrated STEM in elementary schools.

Blank (2013) conducted mixed-methods research to demonstrate the implications of achievement based on STEM instructional time. Trends of instructional time were analyzed using SASS data as well as teacher surveys. The results showed that the decline of time given to STEM instruction led to a decline in assessment performance in STEM areas. The responses to the survey given to teachers also proved more instruction was given to core subjects than to STEM areas. Mixed-methods research uses three fundamental principles to determine the strength of the study: (a) corroboration of the findings, (b) decreasing or minimizing key plausible alternative explanations for conclusions drawn from the research data, and (c) elucidating the divergent aspects of a phenomenon (Tashakkori & Teddlie, 2003). Weaknesses may be demonstrated within the group assessed on the NWEA. These factors may include unrepresented sample populations, time, and absences of participants.

Synthesis of Research Findings

Education in STEM utilizes an integrated, hands-on approach to learning. Students use problem-solving skills and hands-on learning to solve real-world problems. The culture of schools has changed dramatically and evolved into an increased need for such skills. Avery and Reeve (2013) stated that in order to help the United States stay globally competitive in innovation and invention, the teaching of STEM should become a priority in K–12 education today. Education in STEM should also provide more engineering content during precollege education with the themes of innovation and engineering (Bybee, 2010). The United States will need to educate an additional 1 million STEM professionals over the next decade to maintain its global leadership position and meet economic challenges (Molina et al., 2016). Employment projections for occupation groups show that from 2010 to 2020, life science occupations (i.e., genetic scientists) will grow 20%, engineering occupations will increase 27%, and computer and mathematical occupations will grow 22% (Lockard & Wolf, 2012).

More schools have begun to implement career technical education (CTE) programs within their curricula. Within the Mid-Atlantic District, the site of this study, there are many CTE programs that students may take for certification such as mechanics, technical drawing, and engineering (Mid-Atlantic District, 2017). The CTE programs demonstrate STEM use and the validity STEM has for these trade careers. A review of the literature identified various articles pertaining to professional development and STEM, STEM and higher learning, as well as STEM and instruction time. The focus of the present research was to determine if STEM in elementary schools increases assessment scores in Grade 4 state assessments. Most of the research to date has not examined STEM in elementary schools. Various levels of data and information relevant to this research was been provided. For example, Brown (2012) explored the research base of STEM and suggested that a one-size-fits-all approach is not needed for STEM projects. The focus of the research was on how STEM intervention program can be effective. DeJarnette (2012) focused on initiatives and important government and private agencies in providing earlier STEM exposure. The National Science Board (2010) reported a strong correlation between students who take advanced science and math courses in high school and their enrollment and success in four-year college institutions. Each of these studies illustrated the importance of STEM instruction at an early age.

Low student desire and enrollment in STEM studies is a matter of national and international concern (Billiar et al., 2014). Beekman and Ober (2015) stressed the importance of eliminating gender gaps in math and science. By creating a pathway of STEM, it emphasized the ability to capture the interests of girls at an early age. In this study, the authors identified two major points of concern. First, the focus of STEM usually did not begin until high school. Second, the international community stressed STEM from an early age (Beekman & Ober, 2015). This underscored the need for the United States to devote more time and resources to elementary students to increase their desire for STEM and ability to perform in STEM areas.

There is a direct correlation between the amount of time spent on STEM and assessment scores. When more time is devoted to the areas aligned with STEM instructional practices, overall science scores improve. Blank (2013) stated trends over time from 1994–2008 in Grades 1–4 demonstrate a decline in science instruction. Time for elementary science declined from 2000–2008, and overall core academic subjects increased (Blank, 2013). Elementary science instruction in 2008 was at the lowest number of hours per week, as a national average, since trend data on the measure began (Blank, 2013). Thus, educators must strive to achieve a balance between core subject areas and science. Claymier (2014) discussed the correlation between language arts skills and collaboration with colleagues, which, when combined, produced successful STEM integration. This is a significant challenge in K–12 schools. By the time students reach middle school, their interest in STEM careers has already been formed (Daugherty et al., 2014).

Another STEM challenge is integrating STEM in low-income areas. Molina et al. (2016) discussed the limited access of STEM resources for children living in poverty. Low-income areas need more mandated funding for STEM in schools. Schools should be able to design a plan that incorporates STEM in core areas of learning. This would peak the interest of students as well as prepare them for real-world learning and problem solving.

The literature has demonstrated a strong correlation between STEM and student performance. Many researchers have utilized pilot programs and examined at pre- and post assessment scores. However, this only measures a small quantity of students. Quantitative data had been used to compare similar schools to see if STEM interventions increase scores over time. However, studies have yet to compare one grade level and the effect STEM has on state assessments. The MAP measures what students already know and what they need to learn. Harwell et al.'s (2015) research was most highly related to this research in terms of its use of MAP. The issue with the MAP assessment, however, was that is does not specifically target engineering topics, and questions may not be directly related to state standards. However, the MAP assessment is the best available assessment to provide evidence of achievement in a targeted grade level.

Cross-curricular instruction involves an approach to a topic that includes contributions from several different disciplines and viewpoints. Deeper learning can be accelerated by consolidating efforts and combining relevant contents, opening up new knowledge (Johnson, 2013). In order for a cross-curricular approach to take place, there are several factors involved, including: (a) engagement of students and teachers in deep learning, (b) having enthusiastic partners, (c) intensive preparation, (d) assessments that mirror learning, and (e) collaboration (Johnson, 2013). There are three phases to a cross-curricular approach. In the first phase, teachers collaborate with other subject areas and forge in the same direction together to develop questions as a foundation (Johnson, 2013). The second phase involves cooperative collaboration, where teachers synchronize their approach of subjects in a way that enhances each academic area. For example, a social studies teacher may incorporate mathematics into a social studies question just as a mathematics teacher may use social studies in mathematics (Johnson, 2013). The third approach to cross-curricular teaching is conceptual collaboration, which happens when teachers have a conceptual understanding of another academic area (Johnson, 2013). When teachers combine their understanding and reinforce learning, students gain more knowledge and skills.

Cross-curricular integration allows students to analyze when to apply the knowledge they have learned and encourages them to examine relationships between multiple concepts (Froyd & Ohland, 2005). Cross-curricular integration within the intervention is crucial to STEM learning because it connects all subjects to real-world situations (Froyd & Ohland, 2005). Literacy, systems-thinking, self-development and self-management all have been identified as a proponent of STEM education and supports STEM integration in all subjects (Froyd & Ohland, 2005). Integration of STEM into other disciplines of study includes six factors: (a) a form of motivating and engaging in the context; (b) an engineering design challenge; (c) opportunity to succeed and fail promoting redesigning; (d) inclusion of math or science content, (e) student-centered study 6) an emphasis on collaboration and communication. Integrating STEM cross-curricular introduces the use of an engineering design challenge to address a real-world problem (Moore, Glancy, Kersten, & Smith, 2014).

In a similar model, Drake and Burns (2004) described the three concepts of an integrated curriculum: (a) correlation, (b) fusion, and (c) integration. Each concept is essential in bridging the subjects within the classroom. Teachers correlate their instruction and focus primarily on a core theme (Drake & Burns, 2004). Relationships between two or more subjects are demonstrated through teaching a specific theme. Fusion may entail basic skills. For example, teachers may fuse skills, knowledge, and attitudes into the general school day by embedding a core value or theme throughout all subject matter (Drake & Burns, 2004). Teachers may connect the theme to activities that can be completed in any subject over the school year. In integration, teachers organize certain skills based on thematic concepts identified in core subjects. Integration is done through writing and focusing on the "big idea" of the concepts taught (Drake & Burns, 2004). The integrated curriculum differs from a cross-curriculum because it focuses on a theme throughout the year. Teaching in STEM is better suited for cross-curricular instruction based on the collaboration of teachers and other subject areas. The cross-curricular approach to STEM incorporates conceptual learning within other academic areas (Johnson, 2013).

Critique of Previous Research

Current research has illustrated examples of elementary-level, integrated STEM learning in various forms. Yoon et al. (2014) examined the effects of integrated STEM on elementary students' knowledge and identity development. The results supported Piaget's cognitive development, wherein students construct an understanding of what they know and use what is discovered to form their own ideas. Instructors should ensure that the learning environment should be rich in physical experiences because growth in any one stage depends upon activity (Simatwa, 2010). Piaget suggested that active school involvement is the key to intellectual development and should include direct physical manipulation of objects (Simatwa, 2010). Children must experience and understand their environment. Teachers were offered professional development for a week to determine if integrated STEM would increase academic scores in three grade levels. The challenges of this study include the ability to construct an assessment that is developmentally appropriate for elementary students in STEM. Yoon et al. (2015) stated the lack of a valid and reliable instrument that measures students' content knowledge in STEM areas is a hindrance to studying the effects of STEM-integrated education at the elementary school level. In this study, pre- and posttest differences were analyzed using a two-way ANCOVA. The gaps within the study were: (a) the limited amount of teachers offered professional development, (b) the lack of grade-level focus, and (c) no clear assessment for STEM. Future studies would benefit from focusing on a clear assessment to analyze the implications of a STEM-integrated classroom.

Gamse et al. (2015) used STEM experts to work with K–12 students. The purpose was to enhance their attitudes and outcomes in STEM-related subjects. A meta-analytic review was conducted to identify programs and strategies that enhance student attitudes. The research demonstrated relevant versus irrelevant STEM topics that enhance student outcomes. Within this study, the authors reviewed 29 studies from 1986–2013. There evidence showed tremendous impacts in K–12 students when instructed by STEM experts.

DeJarnette (2012) discussed the importance of incorporating STEM at an early age. The NSB (2010) study was conducted in relation to preparing students to be lifelong science learners. Problem-solving skills as well as everyday critical thinking build confidence in students and prepare them for the real world. The study found that learning from textbooks was keeping students out of science (DeJarnette, 2012). Science classes should promote problem solving, critical thinking, and inquiry (DeJarnette, 2012). The biggest challenge for elementary STEM educators is scheduling time for science based on the core subjects taught within a day (McGrew, 2012).

Chapter Summary

There is a wealth of quality data on the implementation of STEM programs and theories in today's schools. The conceptual framework of Gardner (1993) and Piaget (1952) provide a foundation for STEM learning. The literature demonstrates that the core values of STEM are designed to improve student performance and should be included at an early age. However, as noted above, there are significant gaps in the literature and potential for further research. Scheduling remains difficult in an era of language arts and mathematics; however, it must be done to increase STEM collaboration and hands-on learning. The literature demonstrates that there is a need to increase the quantity and quality of STEM in elementary schools. As technology evolves, the United States must invest in STEM programs and professional development. Providing resources, access, quality STEM educators, and real-world problem solving are the key to a successful STEM curriculum in the U.S.. STEM paves the way for students to incorporate new ideas and skills in and out of the classroom.

The emphasis on standardized testing has diminished the confidence and ability of students to form real-world problem-solving skills. The NWEA provides data that can be utilized to guide STEM intervention in elementary school. The NWEA provides a good assessment for students to find out what they know and need to know in the future. The NWEA is a way to measure student growth over time. Teachers can analyze the data from the NWEA and use this data to inform their instruction in all areas of the curriculum. Students can also be differentiated and grouped by their scores for instruction in reading and mathematics. The NWEA is user friendly as well as easily accessible to both teachers and administrators. By increasing pedagogical knowledge, students may have greater success on assessments. U.S. leaders have a great opportunity to implement STEM initiatives and achieve long-term success in

STEM if it invests in children at an early age. This review of literature provided the necessary foundation and knowledge for the current study, which aimed to contribute to this body of knowledge. Prior initiatives, such as NASA, paved the way for future government initiatives through STEM education.

Chapter 3: Methodology

The conceptual framework is reflected throughout the use of many different theories within the study. The Observational Learning Theory reinforces learning through the modeling of others and provides an opportunity for individuals to learn skills through observing. The Constructivist Theory focuses on real world experiences, social connections and prior experiences. The Kinesthetic Theory uses visual, auditory and hand on learning for exploration. Lastly, the Cognitive Theory utilizes the stages individuals go through while learning. All of the theories incorporate how students learn within STEM.

Time spent on science has decreased year after year. Not all students have the opportunity for STEM interventions. The study sought to explore whether having a STEM intervention would correlate with growth measured by the NWEA. The goal of the study is determine if having a STEM intervention in Grade 4 increased English Language Arts and Math scores on the NWEA. The design used for the study is a quasi-experimental design there is an experimental group and a control group. The experimental group will receive the STEM intervention one day a week for 40 minutes over 36 weeks. The control group will not receive the STEM intervention. Each group took the NWEA in fall and spring for English Language Arts and Mathematics. Scores were analyzed and compared to determine if having a STEM intervention produced higher scores on the NWEA in English Language Arts and Mathematics.

The study compared two similar groups of Grade 4 students from two schools in one school district using NWEA data. The control group (School B) did not undertake a STEM intervention throughout the year, while the intervention group (School A) attended STEM class once per week throughout the year for 40 minutes per week. Results from the NWEA determined whether having a STEM intervention increased NWEA scores in English language arts and mathematics. This chapter describes the study methodology. Research questions were used to guide the methodology and justify the study design. The target population for NWEA assessment data collection was crucial in determining the success of the STEM study.

Students in the intervention group were scheduled one day per week for 40 minutes in the STEM lab over 36 weeks. The STEM lab materials promoted hands-on collaboration, problem solving, and inquiry. Each student had a STEM notebook for writing and analyzing information. The ESP Science STEM kits were utilized to incorporate a different STEM intervention each week. Within the ESP unit, specific topics were studied each month. For example, students studied animals, electrical circuits, mystery matter, magnets, and design technology. Supplemental material accompanied the STEM kits for continued learning in the students' own classroom. During the 40 minutes, students explored, analyzed, problem solved, and documented the lesson.

Purpose of Study

The purpose of this quasi-experimental design was to test the theory of kinesthetic learning, comparing students not exposed to a STEM intervention to students in the same district exposed to a STEM intervention once per week, as determined via the NWEA assessment for an initial sample of 260 students in the Mid-Atlantic District. The convenience sample of 256 was used for the study The study determined whether students scored higher on the NWEA if they had been exposed to STEM 40 minutes per week over 36 weeks versus students that had not been exposed to STEM 40 minutes per week over 36 weeks.

Research Questions

RQ1. To what extent, if any, will students that have a STEM intervention one day per week demonstrate increased NWEA English language scores on state tests?

RQ2. To what extent, if any, will students that have a STEM intervention one day per week demonstrate increased NWEA mathematics scores on state tests?

Hypotheses

$H_1$0. There is no significant increase in NWEA English language scores among students that attend STEM intervention once per week from September to June.

$H_1$1. There is a significant increase in NWEA English Language scores among students that attend STEM intervention once a week from September to June.

$H_2$0. There is no significant increase in NWEA Mathematics scores among students that attend STEM intervention once per week from September to June.

$H_2$1. There is a significant increase in NWEA Mathematics scores among students that attend STEM intervention once a week from September to June.

Research Design

This quantitative quasi-experimental study identified the extent to which access to a STEM program increased overall language arts and mathematics skills for a fourth-grade student population. The design was a quasi-experimental design in which subjects were randomly assessed using an experimental and control group. A quasi-experimental design was chosen based on the accessibility of the experimental group and the control group as well as similarities within the district. A quasi-experiment is a design with an experimental and control group without random assignment of participants to the groups (Gall, Gall, & Borg, 2010). The experimental design is a procedure in quantitative research whereby the researcher determines whether the materials or interventions make a difference in the results of the study on the participants (Creswell, 2013). In this design, the experimental group was exposed to the STEM Intervention, where the control group only received instruction via the traditional science curriculum. Both groups took a pretest and posttest. Only the experimental group receives the treatment. The groups were selected via convenience sampling because they are available and willing participants in the study.

In a quasi-experimental design, one or more of the variables are changed in order to demonstrate the effect the changes have on the other variable. In the statistical design of this experiment, the data were gathered and analyzed in order to produce a conclusion based on the information gained from the assessment. The paired t-test is used to determine whether the mean of a population differs from the mean of another population (Creswell, 2013).

A quasi-experimental design was chosen due to the availability of the participants as well as the information available from the NWEA. The information was used in the study through analyzing NWEA scores and determining if growth was evident on the assessment in relation to having a STEM intervention. The test was carried out on both groups to assess the effect of the intervention over time. Random selection provided the groups with equal chances of being represented in the population. The design was measurable and readily available. The design aligned with Tolman & Honzik's observational learning, where students learned based on repetition to achieve a specific end goal.

Activities in STEM are very goal-oriented within the classroom. For example, students were given a challenge to work on collaboratively to reach a certain goal. This behavior was demonstrated through Tolman's use of the lab rat (Tolman & Honzik, 1930). The rat was challenged and ultimately, through trial and error, was able to meet the goal of finishing the maze. The design was a good fit for STEM because in STEM, students are goal oriented and use critical thinking and problem solving to finish the task at hand. The theory provided information based on performance through observing others and acquiring knowledge through observation.

For this study, the intervention group consisted of a convenience sample of 256 fourth-graders who participated in a STEM program one day per week for 40 minutes from September 2016 until June 2017. The comparison control group did not have access to this programming. Data were collected using the NWEA to determine student growth in English language and overall mathematics. Results of the research demonstrated knowledge taught through STEM directly related to NWEA outcomes versus a non-STEM environment in a similar school. Student outcomes included: (a) increased English language scores on state tests, (b) increased mathematics scores on state tests, and (c) increased scores in writing in the science field.

Target Population and Sampling Method

Target Population

This quantitative study determined if access to a STEM program increased overall language and academic skills for a fourth-grade student population. The students chosen for the convenience sampling were chosen from two similar schools in the same district. Convenience sampling was used consisting of 256 Grade 4 students that participated in a STEM intervention one day per week for 40 minutes from September 2016 until June 2017. This sample was chosen based on the availability of the sample and access to information of the students. Students were separated in experimental and control groups based on the school that participated in the STEM intervention. Therefore, the experimental group (School A) received the STEM intervention and the control group (School B) did not receive the intervention. The initial sample population size was 260 students. The sample size of the students was 256, which means this is the number of completed responses on the assessment. The confidence level is 95% with a margin of error of 5%. In Grade 4 are required to take the NWEA and test scores are readily available 24 hours after the assessment. These schools were chosen based on the location and proximity to each other within the district. They are similar in population as well as demographics. A comparison control group did not have access to this intervention.

Sampling Method

Data was collected using the NWEA to determine student growth in English language and overall mathematics. A convenience sample was taken from the population studied. Convenience Sampling is a procedure in quantitative research for selecting participants. The participants are easily accessible and similar. It means that each individual has an equal probability of being selected from the population, ensuring that the sample will be representative of the population (Keppel, 1991). A Power Analysis provides the researcher with information regarding the sample. The sample size is important because it may affect the significance of the study (Yuan & Maxwell, 2005). A Power Analysis can be useful for the planning of sample sizes before a study is being conducted (Yuan & Maxwell, 2005). The population size was 256 with a 95% confidence level given a margin of error of 5% meaning the statistics will be 5 points of the real population 95% of the time. When the size of the population is increased the margin of error decreases.

Convenience sampling is an unbiased and independent sampling method. With convenience sampling, the students are selected because of the convenience and accessibility to the researcher. The specific grade level and type of assessment used provided growth and achievement gaps within the study. Within the Mid-Atlantic District, two schools comprised the focus of this research that had similar demographics, geographical location, and overall student population. The demographics for School A were 45% Caucasian, 34% Hispanic, 14% African American, and 7% other, with 63% free and reduced lunch. The demographics for School B were 54% Caucasian, 29% Hispanic, 8% African American, and 9% other, with 56% free and reduced lunch (Mid-Atlantic District, 2017). School A had a student population of approximately 1,000 students with $130–144 instructional expenses per child. School A was a K–5 building with over 40 classrooms. School B had a student population of approximately 800 students with $130–144 instructional expenses per child. School B was a K–5 building with less than 40 classrooms. Both schools were located in the Mid-Atlantic District. The population of these schools was similar with predominantly Caucasian and Hispanic students (Mid-Atlantic District, 2017). The Mid-Atlantic District median household income was $70,154 with a 20% poverty rate (Mid-Atlantic District, 2017). Within the district, over half of students had free or reduced lunch.

Lack of Evaluation of an Elementary STEM Intervention

Research has provided substantial data on high school STEM programs as well as science in preschool. However, little information is available on elementary STEM intervention evaluation in grade school. In order to have a successful STEM intervention, there must be a way to evaluate STEM at the elementary level. It was important to review research on elementary STEM. In preschool, students were observed in exploratory play in a pretest and posttest program. Within this 6-week program, students were guided in spontaneous play activities such as sorting and slope and speed (Dejonckheere et al., 2016). In this experiment, the children repeated the activities and were observed. The exploratory behavior was classified into four conditions: (a) manipulation, (b) repetition, (c) varying, and (d) observing effects (Dejonckheere et al., 2016, p. 540). The results of the study supported the literature from Tolman & Honzik (1930) on observational learning and repetition. The study found that students performed at a higher level based on the amount of repetition and exploration. Students that did not receive this exploration did not perform at a higher level (Dejonckheere et al., 2016).

In elementary grades, the NWEA provides an assessment of the skills acquired from STEM based on repetition of skills gained from observational learning within the classroom.

Instrumentation

The NWEA can be used to measure the success of the STEM program alongside the New York State Assessment ("NWEA Home," n.d.). Founded by educators nearly 40 years ago, NWEA is a global, nonprofit educational service organization known for the flagship interim assessment, MAP. More than 7,400 partners in U.S. schools, districts, education agencies, and international schools offer prekindergarten through Grade 12 assessments that accurately measure student growth and learning needs, professional development that fosters educators' ability to accelerate student learning, and research that supports assessment validity and data interpretation ("NWEA Home," n.d.). The MAP is used in over 20% of school districts throughout the nation (Cordray, Pion, Brandt, & Molefe, 2013). The NWEA measures growth from September to June and is assessed twice a year. To ensure test validity across all populations tested, the NWEA Research team regularly conducts a variety of studies and analyses such as: pool depth analysis, test validation, comparability studies, and Differential Item Functioning (DIF) Monitoring item quality to ensure that functioning remains constant across subgroups of students when ability is controlled (nwea.org). Every question on a MAP Growth assessment is calibrated to the RIT scale, which is the most reliable in the industry due to the interval scale across grades (nwea.org, n.d). The equal-interval scale is continuous across grades, educators can trust it to track growth over time.

The banks of questions used on the MAP Growth tests are extensive and have been developed over many years (nwea.org). NWEA test and re-test studies, which evaluate scores from the same students after a lapse of several months as opposed to several days, produce reliability indices that have consistently been above what is considered statistically significant (nwea.org,n.d). One of the most common available assessments is the NWEA (Cronin et al. 2007). The NWEA assessments are used in more than 10% of K-12 districts in the nation (Cronin et al 2007). The developer has produced reports on the reliability and validity of the NWEA and operates the largest repository of student growth data in the country (Cronin et al 2007).

The New York State Assessment is assessed in March and measures English language performance in relation to questions in science. The bank of questions used on the MAP growth tests were extensive and developed over many years, lending to their reliability ("NWEA Home," n.d.). Several NWEA test and retest studies, which evaluated scores from the same students after a lapse of several months as opposed to several days, have produced reliability indices that have consistently been above what is considered statistically significant ("NWEA Home," n.d.). The NWEA was administered as a computer-based assessment in September 2016 and June 2017 measuring Grade 4 students in both the intervention and control groups. Scores were readily available within 24 hours of the assessment.

STEM Intervention Implementation

The 40-minute STEM intervention began with a focus question regarding the subject to be studied. The lesson synopsis, learning target, and lesson description were communicated to the students. Once the background information was disseminated to the students, vocabulary was addressed in preparation for the experiment. During the experiment, the phenomenon or targeted question for the unit was addressed with the students. The experiment was conducted, and discussion questions were completed with students in their journals. Toward the end of the 40-minute lesson, the instructor closed the lesson with relevant questioning pertaining to real-world situations. Upon leaving the STEM intervention, general teachers were given cross-discipline lessons so that instruction could continue with regards to the topic covered in the STEM intervention.

Within the district, intervention group students had this 40-minute STEM intervention once per week for 36 weeks. A variable within the STEM intervention was time. Baker, Fabrega, Galindo and Mishook (2005) stated the actual time refers to the number of days in school, hours in courses, or even minutes on task. Time as a resource has also been the focus of block scheduling research, which looks at the efficacy of expanding the blocks of time students are in contact with the specific intervention (Baker et. al, 2005). Forty minutes per week for the intervention may not have been enough time to see a difference in growth within STEM. Increasing instruction time in school is a central element in the attempt to improve student learning; however, an increase in time may have effects on student behavior (Andersen, Humlum, & Nandrup, 2016).

Elementary Science Program

The ESP within the Mid-Atlantic District provided a hands-on approach to learning that was exciting while students learned to problem solve and inquire through science. Each grade level was given a STEM kit that included a unit overview with worksheets that mirrored the lessons. As students attended the STEM lab, each intervention was designed to promote collaboration and problem solving by using different instructional topics of learning. In combination with the STEM kits, there were supplemental units that corresponded with the traditional learning in the classroom involving read-aloud and mathematical learning. The program was designed to blend what is learned through the STEM kit with classroom learning.

Adopted in 2018, the Next Generation Science Standards contain a strong STEM-based focus for all K–12 curricula (MacDonald & Maurer, 2015).

Data Collection

Students were chosen via convenience sampling in the same grade level and district. Each Grade 4 class in the experimental group (School A) and the control group (School B) was scheduled to take the NWEA in September and June. Students were assigned through convenience sampling method based on the availability and willingness of the participants. Students participated in the assessment via the computer lab. Students answered questions in English Language Arts and Mathematics electronically untimed. Data was collected from the NWEA one time in the fall and one time in the spring. Test scores from the NWEA were readily available via computer 24 hours after students took the test. Each test provided a scale score by student, mean and median, and gender. The scale scores were compared to the normative data chart for each grade level.

The quasi-experimental design attempts to determine if there is a relationship between the groups by comparing an experimental group to a control group. A paired t-test was performed to determine whether the School A and School B measured differently on the NWEA. The paired t-test determined the probability that a significant difference between the experimental group (School A) and the control group (School B) of measures existed. Skaik (2015) stated a paired t-test is appropriate for data in which the two samples are paired, such as the following examples: (a) pairs consisting of before and after measurements on a single group of subjects, (b) two measurements on the same subject, and (c) subjects in one group paired or matched on a one-to-one basis with subjects in a second group.

Operationalization of Variables

The study consisted of 256 Grade 4 students in different elementary schools. Each school assessed their students with the NWEA at the same time throughout the year. It was given once in the fall and once in the spring. The NWEA was not a timed test and measured proficiency in English language arts, mathematics and science. The variable included exposure to STEM intervention once a week from September 2016 to June 2017. Student growth was measured using the NWEA Normative Data Chart. The Normative Data Chart ranked students in proficiency from the beginning of the test in September until the end test in June. Students that received STEM were given auditory, kinesthetic, and visual instruction to differentiate the intervention. Students in the STEM lab followed the STEM intervention from September until June. The Boces4science intervention collaboratively retooled STEM by modernizing the intervention and developing shared science resources to prepare students for careers in research and development, sciences, and fields such as next generation manufacturing and technology; optics, photonics, and imaging; and higher education and research (Boces4science.org, 2018).

Data Analysis Procedures

Data was analyzed using a paired t-test for the population in both the experimental and control groups. The paired t-test is used to determine whether two groups differ significantly from each other over a specified population (Gall, Gall, & Borg, 2010). The data was analyzed using the paired t-test comparing fall English Language Arts and Math NWEA scores amongst two schools. The paired t-test can be used to determine whether the scores for the two groups are statistically different (Gall, Gall, and Borg, 2010). The quantitative data analysis is important to identify patterns and construct a framework for communicating what the data reveals (Creswell, 2013). Data was also compared in the spring for English Language Arts and Math using the NWEA scores. This data determined if there was a statistical difference between the two schools on the NWEA. Two sets of data from the NWEA in English language arts and mathematics were analyzed using this test. The data were applied to determine the effectiveness of having an elementary STEM intervention by analyzing growth in the NWEA scores from fall to spring. The students' scores demonstrated that the STEM intervention increased overall growth performance scores on the NWEA tests throughout the district.

Limitations and Delimitations of the Research Design

Limitations of the Research Design

One limitation of the study was the amount of time (40 minutes once per week) students were exposed to STEM, which was determined based upon other scheduling demands. This time allocation was not enough time for the students to complete the hands-on activity with the written instruction piece that accompanied the lesson. A second limitation was the lack of diversity within the demographics based on participants selected from the same school district in Mid-Atlantic District.

Delimitations of the Research Design

The study was conducted in a Mid-Atlantic District and was not expanded to other parts of the region. Student attendance was also a limitation. All students took the test and were offered a make-up test if they missed the initial assessment. However, students were only offered one make-up test. Students that were new to the district were required to take the test. All Grade 4 student scores were included in the research. Students that were not exposed to the STEM intervention and had not been given the same instruction as other students were at a disadvantage. The researcher was the only elementary STEM instructor. If the researcher was absent, the classes were cancelled and students did not receive STEM intervention for that day, though they were rescheduled during the week.

Internal and External Validity

Various factors may enhance or taint NWEA scores, including: (a) student maturation, (b) psychological factors, (c) building climate, and (d) fatigue. These factors may skew the results of the NWEA as well as the paired t-test. Studies refer to more holistic STEM learning versus grade-specific learning. To ensure validity, the NWEA research team conducted a variety of studies and analyses including pool depth analysis, test validation, comparability studies, and differential item functioning to monitor item quality to ensure that functioning remained constant across subgroups of students when ability was controlled ("NWEA Home," n.d.). Students were given an identification number prior to testing. The identification number is inclusive to each student and contains scores from the NWEA. Validated achievement and growth data, including a series of validity studies, concurrent and predictive validity, criterion-related validity, and construct validity, is the flagship of the MAP assessment ("NWEA Home," n.d.).

Reliability is a set of indices of a test of consistency. This consistency refers to performance of the test over a period of time, across items or parts of the assessment. The reliability of the NWEA is measured based on the test administered twice within a period of months to the same students ("NWEA Home," n.d.). The Pearson correlation coefficient (r) suggests an acceptable correlation considered to be .80; 1.00 is a perfect correlation. The two tests would have the same number of items, same structure, with the same difficulty levels measuring content ("NWEA Home," n.d.). The NWEA uses a test-retest to determine reliability spread across 7-12 months. The second test administered is not the same test as the first test.

The second test differs in the level of difficulty of the items. Given this information, it would not seem unreasonable for the reliability to drop below .80 (“NWEA Home,” n.d.).

Content validity of NWEA tests is demonstrated by carefully mapping existing content standards from a district or a state into a test blueprint. Test items are selected for a specific test based on their match to the content standards as well as on the difficulty level of the test being created. In addition, every effort is made within a goal area or strand to select items with a uniform distribution of difficulties (“NWEA Home,” n.d.). The NWEA administered was reliable and valid yet convenience sampling was not a good way to demonstrate validity. Randomizing the sample would have been a more precise tool to use to determine validity.

Expected Findings

The researcher expected to determine if the implementation of a STEM intervention from September to June for 40 minutes one day a week increased NWEA scores in English Language Arts and Mathematics for the experimental group (School A) and the control group (School B).

Ethical Issues in the Study

The researcher served as an observer within the NWEA administration site. Once students were administered the NWEA, the researcher received a printout of their scores from the schools’ principals to analyze. To ensure confidentiality a student identification number was assigned for the assessment. The researcher’s role did not present any potential conflict of interest or bias in this study. Teachers were informed about the research study after the assessment. The researcher was a teacher in one of the elementary schools. All test results were computed by NWEA and released only upon password verification to designated individuals. Scores were readily available via computer 24 hours upon test completion. Each student had his/her own login and identification number. Administrative access was granted to those teachers directly affected by NWEA results. Student scores were progressive and could be seen throughout the student's yearly schooling.

Chapter Summary

The main purpose of this research was to examine the effects of an elementary STEM intervention on the NWEA scores of 256 Grade 4 students in an intervention versus control group. Using a quasi-experimental design between the experimental group and the control group was performed to determine if there was a relationship between the two group. Students were selected through convenience sampling methods based on the availability and willingness of the participants. The experimental group and the control group was compared to determine if having a STEM intervention would demonstrate increased scores on the NWEA. A paired t-test was performed to determine if there was a significant difference between the experimental and the control group. The quantitative data is used to analyze important patterns and construct a framework for communicating the data. The outcomes of the NWEA scores provide the Mid-Atlantic District with an assessment of the efficacy of a STEM intervention for the district.

Chapter 4: Data Analysis and Results

The purpose of this quantitative study was to determine the effectiveness of a STEM intervention among fourth-grade students that attended a STEM lab once per week for 40 minutes from September 2016 to June 2017 which is the experimental group (School A). Students' NWEA scores were compared to a control group (School B) that did not have exposure to STEM intervention. Both groups had access to science intervention during the study period. However, the experimental group received an intervention, which consisted of STEM instruction using the New York State STEM Science Kit. Students were assessed on computer by answering multiple-choice questions in both mathematics and reading content areas via the NWEA.

Once the spring and fall data for both the experimental and control groups were collected, a paired t-test was conducted to determine the mean scores of the two groups via statistical examination in mathematics and English language arts. Scores were compared and analyzed to determine if exposure to STEM intervention positively impacted student performance in the experimental group compared to the control group. Data analysis using the paired t-test assisted in determining if STEM intervention was beneficial to the academic achievement of students in the district. Calculations for the paired t-test were done using SPSS, a secure data analysis software program. Descriptive statistics was also used to aid in providing a clear and concise rationale behind the statistical outcomes. The data were analyzed holistically, looking for any patterns, trends, or outliers. Chapter 4 presents the findings and further addresses the methods used to collect and analyze the data for this study.

Research Questions

RQ1. To what extent, if any will students that have a STEM intervention one day per week demonstrate increased NWEA scores in English Language?

RQ2. To what extent, if any, will students that have a STEM intervention one day per week demonstrate increased NWEA scores in Mathematics?

Hypothesis

$H_1$0. There is no significant increase in NWEA English language scores among students that attend STEM intervention once per week from September to June.

$H_1$1. There is a significant increase in NWEA English Language scores among students that attend STEM intervention once a week from September to June.

$H_2$0. There is no significant increase in NWEA Mathematics scores among students that attend STEM intervention once per week from September to June.

$H_2$1. There is a significant increase in NWEA Mathematics scores among students that attend STEM intervention once a week from September to June.

Description of the Sample

A sample of 256 Grade 4 students was selected for this study. The actual fall reading participants for experimental group (School A) and the control group (School B) were 256; therefore 256 participated in the fall reading assessment (98.4%). In the spring, the number of reading participants remained constant as there were 127 participants in both the experimental and control groups, totaling 254 students (97.6%). In the fall, the participants for mathematics in School A (129) and School B (129) were 258; this equaled 99% of the anticipated sample population. During spring assessments, the mathematics participants were 252 (96.9%), which accounted for a decrease in six participants, three from both the experimental and control groups.

During the spring mathematics assessment, there were six students, three students from each school, that transferred out of the district, which lowered the spring participants in mathematics to 126. It is also important to note that there was a potential 5-week gap in between reading and mathematics assessments, which accounted for fluctuation between the fall math and reading groups; this was due to students transferring in and out of the school district.

As shown above, the 256 fourth-grade students were dispersed into two groups: the experimental group (School A) consisted of 127 students from September 2016 to June 2017 in reading. These participants were exposed to the STEM intervention for 36 weeks. The control group consisted of the remaining 127 students in reading during the fall that did not receive the STEM instruction (School B). The experimental group (School A) consisted of 129 participants in mathematics in September 2016. The control group (School B) consisted of the remaining 129 participants in mathematics in September 2016. In June 2017, the participants in School A and School B decreased based on students leaving the district resulting in 256 students in School A and School B that participated in the June 2017 mathematics assessment.

Convenience sampling was used in this study, and all of the students in School A and School B enrolled in school in September 2016. The sample size of the control group did not have the same number of students due to enrollment, as some students left the district. The study included all general education and special education students who were given the same NWEA assessment. Students that attended the experimental group (School A) and the control group (School B) were required to take the NWEA as per district and state policy. The district mandates that any student entering the school district, whether it is in September or later, must adhere to taking the test upon arrival at either school. All students were enrolled in public school in the Mid-Atlantic District. The experimental group from School A received STEM intervention for 40 minutes per week, while the control group from School B did not receive STEM intervention but received the general science curriculum bimonthly.

The study focused on these two schools because of their similar demographics, geographical location, and overall student population. The demographics for School A consisted of 45% Caucasian, 34% Hispanic, 14% African American, and 7% other, with a 63% free and reduced lunch. The demographics for School B consisted of 54% Caucasian, 29% Hispanic, 8% African American, and 9% other, with a 56% free and reduced lunch (Mid-Atlantic District, 2017).

During STEM intervention, students in the experimental group used evidence-based practices via the New York State STEM Science Kit, which utilizes cooperative groups, collaboration, concrete manipulatives, and problem-based learning and inquiry. A critical element of this STEM intervention focused on student application and reflection; students were required to analyze and reflect upon each lesson in an educational journal. This acted as an artifact and documentation of student learning and development. Students in the control group used general science kits within the general education classroom with no hands-on science experiments given. This study determined if STEM intervention had an impact on student performance in the areas of reading and mathematics as measured by the NWEA.

Table 1

Description of Sample

Assessment	Number of Participants	
	School A	School B
Fall NWEA Reading	127	127
Spring NWEA Reading	127	127
Fall NWEA Mathematics	129	129
Spring NWEA Mathematics	126	126

The purpose of this study was to examine differences between the NWEA results of an experimental and control group of 256 Grade 4 students to determine if STEM intervention impacted student growth and performance. A quasi-experimental design was chosen with convenience sampling. A paired-t test was conducted on the data from the NWEA in English Language Arts and Math in the fall and spring. Both the experimental and control group were assessed using the NWEA in September (fall) and June (spring). The fall data were used to create a baseline for both groups and assisted in determining the overall rate of improvement from fall to spring. Scores were determined based on reporting from the NWEA via computer. Each student score was available within 24 hours of participating in the assessment. The assessment was reliable based on the NWEA score report for pre and posttest. The assessment was valid and readily available to access students' scores. Student names and numbers remained anonymous. In the end, both School A and School B demonstrated growth, however there was no significant difference between the scores.

Summary of Results

Findings Associated with Hypothesis 1

A paired t-test was performed to compare the experimental and control groups' test results to identify any differences between their reading and mathematics scores. The NWEA provided students' mean scores in September 2016 and June 2017. The scale score was compared to the normative data provided by the NWEA. The paired t-test was the most logical test for the study based upon the availability of the NWEA results. Within the reading component of the NWEA, students read passages on the computer and answered multiple-choice questions, which targeted overall reading comprehension competencies. At the end of the reading task, students used the computer to write an extended response-based answer for article questions, which focused on an integration of reading comprehension, application, and written expression. The results of the study determine that there is no statistical difference between the experimental group and the control group on the NWEA based on the paired t-test results from fall to spring. Although both groups demonstrated improvement from fall to spring on the NWEA, the results do not prove significant differences.

Table 2 Fall NWEA paired t-test results demonstrates the number of randomly selected students (*n* = 127) for both the experimental and control group in the fall. The experimental group had a mean score of 196.30, while the control group had a mean score of 197.98. This data provided a baseline to determine how much growth each group demonstrated throughout the 36-week intervention period. When analyzed, there was only a 1.68 mean point difference in baseline data between the experimental and control groups. This data demonstrated that both groups had a similar starting point prior to the implementation of STEM instruction. The standard deviation (*SD*) for the experimental group was 16.92, while the control group was 14.25. The *SD* were high in both groups due to the variation of scores being either extremely high or extremely low. When the *SD* was relatively high, the bell curve was relatively flat due to a variation in scores that were more spread out; therefore, the *SD* was larger.

Table 2

Fall NWEA Reading Descriptives

	Experimental Group– Fall NWEA Reading	Control Group– Fall NWEA Reading
n	127	127
M	196.30	197.98
SD	16.92	14.25

Table 3 illustrates the number of randomly selected students (*n* = 127) in both the experimental and the control group for spring in the area of reading. The mean for the experimental group was 203.3 and the mean for the control group was 204.73. The *SD* for School A was 15.71 and the *SD* for School B was 11.98. The means were high due to the variation of spring scores in reading being either extremely low or extremely high. Therefore, the *SD* was larger. Data was collected in September 2016 to determine the baseline of both the experimental and control groups. After the 36-week intervention phase, both groups were reassessed using the NWEA to determine overall growth in the area of reading. Standard deviation was analyzed for both fall and spring data to look for any potential outliers in the data. Although the *SD* was elevated, data was explained by the number of significantly higher and lower scores. Collecting both pre- and post-intervention data allowed for a comprehensive analysis of the increase in overall mean scores from both groups.

Table 3

Spring NWEA Reading Descriptives

	Experimental Group– Spring NWEA Reading	Control Group– Spring NWEA Reading
n	127	127
M	203.03	204.73
SD	15.71	11.98

Figure 1 depicts results from both the experimental and control groups in fall and spring after the 36-week intervention phase. This provides a visual representation of the starting and end points for both groups. A paired t-test was employed to analyze the difference of means from the fall to spring data, which determined overall student growth in reading per the NWEA. The results demonstrated that the experimental group's (School A) mean scores increased from 196.3 to

203.03 with an increase of 6.73 mean points from fall to spring. The control group's (School B) mean scores increased from 197.98 to 204.73 with an increase of 6.75 points from fall to spring.

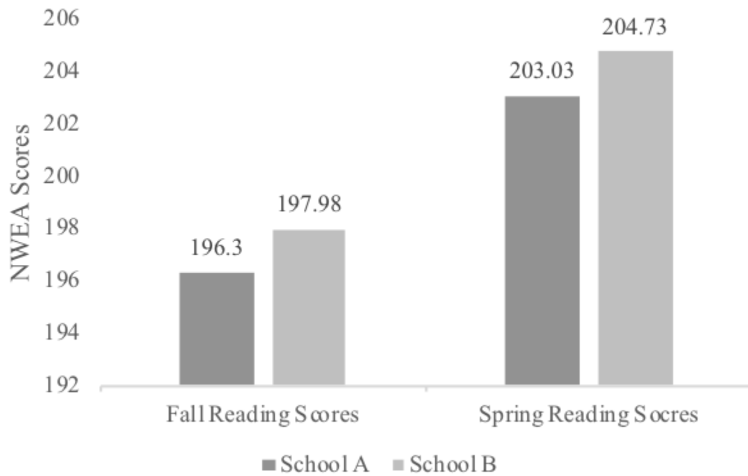

Figure 1. Comparison of reading scores 2016–2017.

Table 4 compares the fall to spring reading scores for the experimental and control groups. The mean for the experimental group in the fall was 196.3 and, in the spring, increased to 203.03, demonstrating a 6.73-point increase from fall to spring. The mean for the control group in the fall was 197.98 and, in the spring, increased to 204.73, demonstrating a 6.75-point growth in scores from fall to spring. After running a paired t-test and analyzing the difference between the increases in mean scores, the *t* value was 0.970. The t value examines the distribution of values and identifies if there is a difference in the sample mean. The *p* value was 0.33, which was larger than 0.05. The degrees of freedom (*df*) are the number of values that scores can move either higher or lower. The *df* was 252, meaning that there were 252 values that were free to vary.

Table 4

NWEA Growth Summary Report for Reading

	Experimental Group–Fall	Experimental Group–Spring	Control Group–Fall	Control Group–Spring
Reading mean	196.3	203.03	197.98	204.73
NWEA norm	198.2	204.2	198.2	204.2
SD	16.92	15.71	14.25	11.98
t value	0.970			
p value	0.33			
df	252			
+/- Reading	6.73		6.75	

The NWEA data scores showed a 6.73-point mean growth in reading within the experimental group from fall to spring. Conversely, the data scores showed a 6.75-point mean growth in reading within the control group from fall to spring.

Based on the paired t-test used to analyze the NWEA reading growth scores, there was no statistical significance between the two groups. The cutoff for statistical significance is 0.05. If the *p* value is less 0.05, the null hypothesis cannot be rejected and the data cannot be determined as statistically significant. The Ha was not accepted as the *p* value ($p < 0.05$) was not significant. The means of the experimental and control groups were not statistically different. The calculated *t* value was smaller than the critical value (0.970 < 1.972), so the means were not statistically different. The *df* was 252, which demonstrated the critical value was 1.972.

The fall NWEA scores in reading demonstrated no statistically significant difference between the schools. Specific paired t-test results for the assessment demonstrated the experimental and control groups were not within the same p value range ($p < 0.05$), determining there is no difference in scores on the overall data collected. The spring results from the NWEA yielded an increased growth score of a 6.73-point mean increase in reading for the experimental group and a 6.75-point mean increase in reading for the control group. Even though both schools demonstrated improvement from fall to spring, there was a no significant difference between the experimental and control groups in reading scores from fall to spring.

Findings Associated with Hypothesis 2

The mathematics data determined if students in the experimental group scored higher on the NWEA than students in the control group. During the NWEA, students completed various mathematics questions via computer and selected the best answer by multiple-choice. The scores were based on data from September 2016 and June 2017 in the experimental and control groups. Table 5 shows the number of randomly selected students (n = 129) for both the experimental and control groups in the fall. The mean was calculated when the sum of all participant scores were divided by the number of participants (n = 129). The mean for the experimental groups was 202.05 and the mean for the control groups was 199.59. The *SD* for School A was 10.57 and the *SD* for School B was 12.48. The means were somewhat high due to the variation of scores on the NWEA fall math assessment. The scores were dispersed either really high or really low.

Table 5

Fall NWEA Mathematics Descriptives

	Group A– Fall NWEA Mathematics	Group B– Fall NWEA Mathematics
n	129	129
M	202.05	199.59
SD	10.57	12.48

Table 6 shows the number of randomly selected students (*n* = 126) in the experimental and control groups in spring. The mean for School A was 209.89 and the mean for School B was 211.96. The *SD* of School A was 11.94 and School B was 14.31 in the spring. The *SD* was high, meaning there were variations in the scores either high or low. The larger the *SD*, the flatter the bell curve.

Table 6

Spring NWEA Mathematics Descriptives

	Group A– Spring NWEA Math	Group B– Spring NWEA Math
n	126	126
M	209.89	211.96
SD	11.94	14.31

Figure 2 demonstrates the overall baseline data in fall and the growth from both the experimental and control groups from fall to spring after the 36-week intervention phase. In the fall, there was only a 2.46-point difference in the two groups, which showed that both groups had very similar starting points. After the 36-week STEM intervention, students were reassessed; spring data demonstrated only a 2.07 difference between the experimental and control groups. Both groups demonstrated significant growth from fall to spring, which indicated that the instruction offered in both schools was effective. However, when compared to each other both schools are not statistically different.

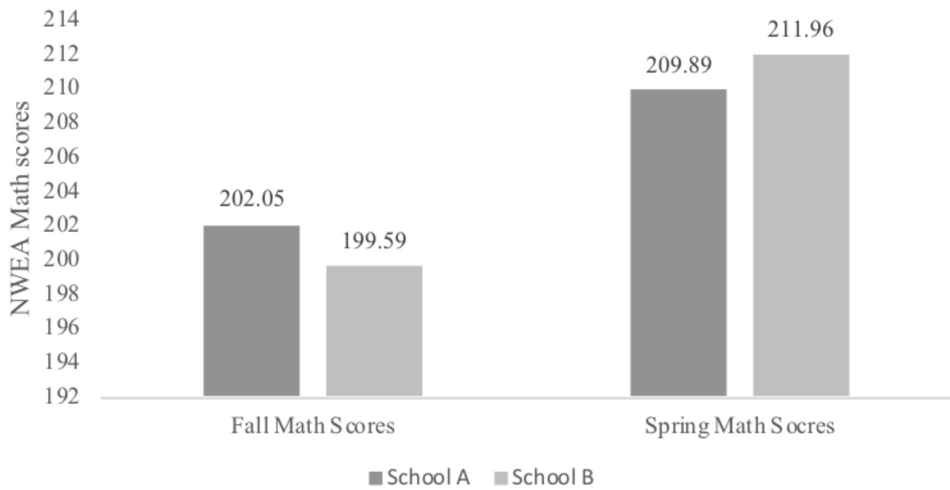

Figure 2. Comparison of mathematics scores 2016–2017.

Table 7 compares the fall to spring scores for the experimental and control groups per NWEA outcomes in mathematics. The mean for the experimental group was 202.05 in the fall and increased to 209.89 in the spring. This demonstrated a 7.84-point mean growth increase. The mean for the control group in the fall was 199.59 and 211.96 in the spring, demonstrating a 12.37-point mean increase. Given the high *SD* for the experimental and control groups and the variation of scores, it demonstrated that some of the scores were significantly elevated and some significantly lower. A paired t-test was conducted to determine the difference between the means of the two groups and to determine the statistical significance between the growth of the means after the 36-week intervention period. The t value was 1.24; this value examined the amount of distribution of the values and determined if there was a difference in the sample of the means. The p value was 0.214, less than 0.05. The *df* was 250, meaning that there were 250 values that were free to vary. The null hypothesis was accepted. The two hypotheses were:

$H_2$0. No relationship exists between students that attend a STEM intervention once per week and students that do not attend a STEM intervention once per week on NWEA in mathematics.

H$_2$1. A relationship exists between students' scores on the NWEA in mathematics. The experimental and control groups did not show a significant difference, because the *t* value was 1.24 and the *p* value was 0.214. Therefore, they did not demonstrate a statistically significant difference.

Table 7

NWEA Growth Summary Report Mathematics

	Experimental Group– Fall	Experimental Group– Spring	Control Group– Fall	Control Group– Spring
Mathematics mean	202.05	209.89	199.59	211.96
SD	10.57	11.94	12.48	14.31
NWEA norm	198.2	204.2	198.2	204.1
t value	1.24			
p value	0.214			
df	250			
+/- Mathematics		7.84		12.37

The fall mean for the experimental group was 202.05 in mathematics, demonstrating an increase in the mean to 209.89 in the spring. The experimental group demonstrated a 7.84-point increase in mean mathematics scores from fall to spring. The control group fall mean score was 199.59 with a spring score of 211.96, giving School B a 12.37-point increase. Therefore, the control group outscored the intervention group in the area of mathematics and demonstrated more growth within the Grade 4 students; however, given the *p* value of 0.214 (< 0.05) which was lower than 0.05, it was not statistically different. As such, the fall to spring results in the NWEA math growth mean scores concluded that there was a 3.88% increase within the experimental group in math from fall to spring. The control group demonstrated a 6.19% increase from fall to spring. The scores were not significantly different based on the results of the paired t-test. Figure 2 displayed results from the paired t-test comparing School A and School B scores.

Detailed Analysis

The fall scores were compared to the spring scores using the mean according to the NWEA. Normative data displayed both groups increased in mathematics and reading from September 2016 to June 2017. School A demonstrated an increase in reading scores from fall to spring by 6.73 points, where School B demonstrated a fall to spring increase of 6.75 points in reading. In math, the experimental group had a fall mean of 202.05 and a spring mean of 209.89, which demonstrated an overall increase of 7.84. The control group had a fall score of 199.59 and a spring score of 211.96, which demonstrated an overall growth of 12.37. Therefore, the control group (12.37 increase) outperformed the intervention group (7.84) in the area of math.

In both areas of reading and math, the control group outscored and outperformed the experimental group. Baseline data were carefully analyzed, and it was determined that both groups had very similar baseline data and starting points. A paired t-test was used to analyze the difference in growth and mean scores statistically, which supported these findings. Chapter 5 discusses this analysis to consider why the outcomes did not support the current literature.

The null hypothesis expected no association between the use of instruction and scores gained by the experimental group in comparison with the control group. Results from the NWEA demonstrated growth in scores from fall to spring in both reading and mathematics within the respectable groups. All of the assessments showed a positive difference in scores from fall to spring. However, statistically, the null hypothesis could not be rejected based on these outcomes, which demonstrated that the STEM intervention had no impact on the difference in testing outcomes.

Chapter Summary

Students in the intervention group participated in two semesters of a STEM intervention. Students were assessed in the fall and spring in both reading and mathematics on the NWEA. When comparing data from fall to spring, the data showed that each group improved growth scores, yet when scores were compared there was no significant difference in reading scores for each school. There was no significant difference in mathematics scores between the experimental group (School A) and the control group (School B in the spring. Each school demonstrated an increase on the NWEA from fall to spring in both reading and mathematics. There is not enough evidence to determine that having a STEM intervention makes a difference on the NWEA growth scores. Therefore, the specific STEM intervention in the experimental group did not make a difference when compared to the control group's general science instruction. Chapter 5 provides further discussion on the data and results of this study.

Chapter 5: Discussion and Conclusion

Today, students are being held accountable for high performance in STEM. Teaching in STEM utilizes a standards-based, integrated approach to learning, in which the curriculum is addressed as one fluid study using a hands-on approach (Brown, 2012). As such, STEM allows for hands-on experiments and meaningful reflection that prepare students for real-world situations. For example, students exposed to STEM intervention may be given the task of building a model of a house with designated items. Students must work collaboratively and design a plan to accomplish the task. Once the design is completed, students take part in the hands-on engineering process of building the model. This problem-based learning model is a core component of STEM instruction. Rincon and George-Jackson (2016) stated one way to demonstrate growth in STEM is by providing hands-on, kinesthetic learning and assessments.

This quantitative study was conducted to determine the potential impact of STEM instruction over a 36-week period. This study analyzed and evaluated two groups to determine if the intervention group had increased NWEA scores in the areas of English language arts and mathematics. The NWEA is a tool used to measure the growth of students via computer through multiple-choice questions twice a year. The NWEA was used to test mathematics and reading in September 2016 and June 2017. The experimental group consisted of 127 Grade 4 students who were exposed to STEM intervention for 40 minutes per week. The control group consisted of 127 fourth-grade students that did not receive STEM intervention but had access to the standard district science curriculum. It is important to note that both the experimental and control groups both had exposure to the standard district science curriculum; however, the experimental group had additional STEM instruction. The general science curriculum does not allow for hands-on experiments and is more literature based. Prior to the study, it was hypothesized that the experimental group would out perform the control group due to the cross-curricular and academic rigor of STEM programming, in keeping with the literature (Becker & Park, 2011).

The framework for this study was based on theories of four diverse types of learning. Education in STEM is comprised of observational, constructivist, kinesthetic, and cognitive learning. Kinesthetic learning in STEM uses all senses when challenged with a task to complete. Felder & Silverman (1988) stated that kinesthetic learning is used through STEM lessons and enhances student learning. The STEM intervention consisted of hands-on experiments that focused on reading and mathematical challenges. Kinesthetic learning was demonstrated when students were challenged to use specific items to build a model bridge. During the instruction, students read articles and collaborated on how to design the best bridge. Once the design phase was completed, students built the model from their collaborative design.

Research Questions

RQ1. To what extent, if any, will students that have a STEM intervention one day per week demonstrate increased NWEA English language scores on state tests?

RQ2. To what extent, if any, will students that have a STEM intervention one day per week demonstrate increased NWEA mathematics scores on state tests?

Hypotheses

$H_1$0. There is no significant increase in NWEA English language scores among students that attend STEM intervention once per week from September to June.

$H_1$1. There is a significant increase in NWEA English Language scores among students that attend STEM intervention once a week from September to June.

$H_2$0. There is no significant increase in NWEA Mathematics scores among students that attend STEM intervention once per week from September to June.

$H_2$1. There is a significant increase in NWEA Mathematics scores among students that attend STEM intervention once a week from September to June.

Summary of the Results

This study was conducted to determine if there was a potential relationship between two groups. The experimental group was exposed to a STEM intervention provided to Grade 4 students one day per week for 40-minutes from September 2016 to June 2017. The control group did not have STEM intervention and engaged in science education through general science instruction within the classroom. The research sought to identify if there was a relationship between NWEA scores in reading and mathematics for the students exposed to STEM instruction. Fall NWEA and spring NWEA scores for both reading and mathematics were analyzed using a paired t-test to determine if a relationship existed between the experimental and control group scores. Dejonckheere et al. (2016) stated that students who participate in spontaneous exploration experience meaningful and informative reflection. The goal was to take those meaningful and informative experiences and apply them to the NWEA assessment based on STEM learning. Avery and Reeve (2013) discussed the importance of building an effective STEM program that incorporates literature, science, and mathematics research and technology.

A initial sample of 260 Grade 4 students was chosen for this study in English Language Arts. In the fall there were 256 students that participated in reading in the experimental group and control group; each group consisted of 128 students. Of the 260 selected students, there were four students that transferred out of the district before the test date in September 2016. Therefore, they were not included in the final results. In the spring, the number of reading participants was 254 for the experimental group and the control group; each group consisted of

127 students. In the fall, there were 258 students that participated in the mathematics assessment in the experimental and control group. During the spring mathematics assessment, there were 252 students that participated; therefore, the final data reflected 126 students in both the experimental and control groups to randomly standardized and even the number of group participants. The overall number of participants accounted for a decrease in six students who left the district prior to testing. The study did not prove that the use of kinesthetic learning in the STEM intervention in the experimental group resulted in higher NWEA scores over the control group, which did not engage in kinesthetic learning. The control group outscored the experimental group in both areas.

Discussion of the Results

The study concluded that there was no significance in reading or mathematics between the experimental and control groups. Both groups demonstrated improvement within their own group from fall to spring in mathematics and English language arts. The results of the study did not align with the expected findings. The study expected to find that the experimental group would score higher than the control group on the NWEA given the experimental group was exposed to STEM intervention 40 minutes, one day per week from September to June. However, the results did not prove this to be true. In fact, there was no significant growth observed from the intervention.

The results of this study may assist teachers and administrators in preparing STEM interventions that are cross-curricular in mathematics and English language arts. Avery and Reeve (2013) stated that to compete globally in STEM, a good STEM curriculum must be developed. The research findings do not support the literature. The literature supports a program that is cross-curricular and has a higher duration of time spent on STEM. Therefore, the

STEM intervention should be examined for gaps within cross-curricular studies. The STEM intervention should be reassessed for continued implementation. The STEM intervention should be implemented more days per week versus one in order to determine if a significant difference is made. Given more STEM intervention time per week, students would have more time to use their skills to enhance STEM performance and utilize more cross-curricular topics. As shown by the scores in Table 2, the student scores on the NWEA fall to spring in the experimental group reading increased 6.73 points. The control group NWEA fall to spring scores increased 6.75 points. In mathematics, the experimental group demonstrated 7.84 points compared to the control group increase of 12.37 fall to spring. The data showed a strong increase within the experimental group in reading, however, when compared to the control group, there was no significant difference in scores in reading. In mathematics, both groups demonstrated improvement, however, when compared there was no significant difference.

The research does not demonstrate a benefit to having a STEM intervention once per week for 40 minutes. Based on the research, 40 minutes one day a week is not enough time for students to attend a STEM intervention. Overall, the students gained growth points over the course of this 36-week intervention. The results from this study is clear: research shows STEM intervention provided for 40 minutes one time a week does not directly benefit students when compared to students without STEM intervention. The NWEA scores may demonstrate more growth if there is more time allotted for STEM throughout the week. Brown (2012) stated that a one-size-fits-all curriculum is not needed for all STEM education. This is true based on the research.

Discussion of the Results in Relation to the Literature

The results of this study reflect the need to develop more time on STEM interventions that best meet the needs of the students. Students must learn to solve problems based on real world applications and promote innovative thinking (Filippi & Agarwal, 2017). Classroom teachers need to adjust their instruction according to the discipline taught and integrate STEM in recognition of potential connections across disciplines (Winn, Choi, & Hand, 2016).

Another important aspect of this study is evaluating the management, planning and execution of a STEM intervention. This pertains directly to Piaget's four stages of development asserting that a child is an active investigator who acts upon the environment and responds with more complex reasoning as they grow (Simatwa, 2010). It is important to also look at the tool that is used to assess students in STEM. Although the NWEA was used to assess students, more assessments need to be analyzed for validity and reliability. An assessment development team of classroom teachers, school curriculum specialists, and academic researchers with expertise in engineering, science and mathematics should provide critically needed test development expertise (Harwell et al, 2015)

Limitations

Two of the significant limitations of this study were attendance and minimal exposure time in STEM. All students were required to take the NWEA. If they were absent on the day of the test, a make-up day was offered. If students missed the make-up day, their score was not counted. Scores also fluctuated due to transiency in and out of district. Another limitation was students that were new to the district may not have had any STEM intervention and were required to take the NWEA. Students that were new to the district were included in this research. The only way to remove their score would be for the district to develop attendance criteria for those students based on how long they had been enrolled in the district when the NWEA is given. The STEM instructor was the only person providing STEM intervention within the district. If the STEM instructor was absent, no STEM intervention took place and classes were cancelled, which have may affect the results of the NWEA. There was no substitute and the classes that were cancelled were rescheduled to take the NWEA another day and time. Students attended STEM for 40 minutes once per week. Based on the research, 40 minutes once per week is not enough time to complete a STEM hands-on activity and writing assignment. Students that spend more than four hours per week on science demonstrate higher scores on assessments versus students that receive science instruction less than four hours per week (Judson, 2013).

There are other factors that may have skewed the research. The first factor is student maturity. Simatwa (2010) stated that in Piaget’s theory of intellectual development, each stage is a system of thinking that is quantitatively different from the previous stage. This means that a student must go through each stage sequentially in development. Students must have sufficient time in each experience in order to progress and move forward. Student socioeconomic factors also play a role in STEM research. Molina et al. (2016) stated that students from low-income communities with limited resources are less likely to learn in a creative environment unless there are many opportunities beyond the learning environment of school. Within the district, there was over 60% student free and reduced lunch in School A and over 50% student free and reduced lunch in School B.

Student burnout is also a factor that may have skewed results. Daugherty et al. (2014) discussed the frequency of high-stakes testing and the requirements placed on students. The increased time spent on high-stakes testing leaves little room for STEM, which directly impacts student performance on exams. This quantitative study was based on paired t-test scores from the NWEA. The paired t-test may not be reliable and violate the assumptions based on the differences in the data among the groups compared, as well as the high and low discrepancy of scores in both groups. The paired t-test compared the difference in means of two samples, however, different results may have occurred with another testing tool such as the Wilcoxon test. The Wilcoxon test compares related samples by assessing their mean differences. Another limitation was the NWEA used as a testing tool. There are other potential assessments that may yield more conclusive evidence when comparing schools. The New York State Science Assessment that is given in the spring once a year in Grade 4 also measures student growth in science. The New York Science Assessment is a two-part assessment combining a hands-on experimental lab with a writing component. This assessment takes two days to complete. However, scores are not available until the following school year.

Measuring only two schools within the same district was also a limitation. The information gained from measuring more than two schools as well as outside of the district could potentially change the information as it stands. Studies and other research that are longitudinal may provide more thorough analysis of whether STEM intervention is effective in schools. The lack of access to other grade-level NWEA data along with the limited number of students compared on the NWEA in Grade 4 is a further limitation. Alternative testing and an increased population of students undergoing should be examined as well.

Implication of the Results for Practice, Policy and Theory

In Chapter 2, the interventions in both STEM and ESP were discussed because they could have possible implications on the results of the study. Both of the interventions take place over a 40-minute period one day per week for 36 weeks. However, the intervention within STEM was more detail oriented for the students with more hands-on activities versus the ESP intervention, which was based on the previous New York State Science Standards with more basal questioning from worksheets regarding the set subjects studied. There were also more units of study within the STEM intervention versus the 10 units within the ESP intervention. This may have led to a discrepancy in the results based on the differences in the interventions given. Another potential impact within the study was the amount of training given from administration with regards to both interventions. The delivery of the intervention from the instructor could have potential impacts due to the level of training provided from administration. The STEM intervention took place over a 40-minute period one day a week for 36 weeks using the STEM Kits. The ESP instruction took place over a 40-minute period one day a week for 36-week. The discrepancies in the instructional strategies may have impacted the results of the study.

Recommendations and Future Research

The purpose of this study was to determine if Grade 4 students in the experimental group demonstrated higher growth scores on the NWEA by having STEM intervention once per week for 40 minutes from September 2016 to June 2017, compared to the control group, which did not receive STEM intervention. A significant relationship was not found between student scores. Based on the results, having STEM intervention for only 40 minutes one day per week may not be sufficient to achieve the expected outcomes. In relation to science in elementary classrooms, instruction time has decreased over the last three decades to an average of 2.3 hours per day (Blank, 2013). The time allocated to the STEM intervention falls far short of even this reduced time. More research is needed with increased time spent on the intervention to determine the efficacy of STEM intervention.

Future research could also utilize more than one school district. This would allow for a larger sample size to be analyzed, yielding a larger volume of data. This would help in determining if the information produced significant results. Comparing schools that are not similar socioeconomically and not in the same district would provide varying information on STEM interventions. Additionally, assessing more than one grade level as well as different grade levels on the NWEA would show differences between different age groups.

Future studies could also replicate this study utilizing other forms of assessment in addition or comparison to the NWEA, such as the New York State Science Assessment. Utilizing the New York State Science Assessment would be helpful because all the questions are science based and contain an element of hands-on work that can be directly related to STEM intervention within the classroom. On another note, writing is a part of STEM that is briefly touched upon in the NWEA assessment. Future research may explore a STEM-based writing assessment.

Another recommendation would be to analyze STEM interventions taught in other districts. The only other elementary STEM intervention in Mid-Atlantic District is taught as an afterschool club. This afterschool program introduces basic computer science to students. At the time of the study, there was no definitive STEM intervention taught in New York State. As of 2018, New York State has implemented the new science standards, which includes hands-on experiments with cross-curricular studies in STEM. Research is needed to investigate the efficacy of the intervention. By looking at the STEM interventions, researchers may find a missing component that may help in increasing student growth.

Future research in elementary STEM interventions and duration on task may lend new ideas and data to assist in developing more ways to analyze and compare whether an elementary

STEM intervention is effective. Within the district, STEM is offered to students K–5 at the elementary level. Students begin with initial exposure in kindergarten and progress to Grade 5 with 40-minute periods of STEM. Unfortunately, in the district the allotted time is 40 minutes due to the length of the school day.

Conclusion

This study aimed to show the value of having STEM intervention for Grade 4 elementary students 40 minutes per week for 36 weeks. The goal was to determine if a STEM intervention would yield higher growth scores on the NWEA compared to general science intervention with no STEM within the classroom. Students included in the sample received STEM intervention via a STEM instructor for 40 minutes one day a week or general science intervention from a classroom teacher. Based on the NWEA scores and paired t-test results, there was a no relationship between having STEM intervention for 40 minutes one day per week and not having a STEM intervention at all with NWEA growth scores. The results of the study were strong enough to indicate that there was no significant value to having this specific STEM intervention. Yoon et al. (2015) stated that there is a significant lack of valid and reliable instruments to determine STEM growth. This study supports the need for alternative research utilizing valid and reliable instruments to determine STEM growth amongst students.

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Appendix A: 2015 NWEA Reading and Mathematics Student Status Norms

NWEA

2015 READING Student Status Norms						
	Begin-Year		Mid-Year		End-Year	
Grade	Mean	SD	Mean	SD	Mean	SD
K	141.0	13.54	151.3	12.73	158.1	12.85
1	160.7	13.08	171.5	13.54	177.5	14.54
2	174.7	15.52	184.2	14.98	188.7	15.21
3	188.3	15.85	195.6	15.14	198.6	15.10
4	198.2	15.53	203.6	14.96	205.9	14.92
5	205.7	15.13	209.8	14.65	211.8	14.72
6	211.0	14.94	214.2	14.53	215.8	14.66
7	214.4	15.31	216.9	14.98	218.2	15.14
8	217.2	15.72	219.1	15.37	220.1	15.73
9	220.2	15.68	221.3	15.54	221.9	16.21
10	220.4	16.85	221.0	16.70	221.2	17.48
11	222.6	16.75	222.7	16.53	222.3	17.68

2015 MATHEMATICS Student Status Norms						
	Begin-Year		Mid-Year		End-Year	
Grade	Mean	SD	Mean	SD	Mean	SD
K	140.0	15.06	151.5	13.95	159.1	13.69
1	162.4	12.87	173.8	12.96	180.8	13.63
2	176.9	13.22	186.4	13.11	192.1	13.54
3	190.4	13.10	198.2	13.29	203.4	13.81
4	201.9	13.76	208.7	14.27	213.5	14.97
5	211.4	14.68	217.2	15.33	221.4	16.18
6	217.6	15.53	222.1	16.00	225.3	16.71
7	222.6	16.59	226.1	17.07	228.6	17.72
8	226.3	17.85	229.1	18.31	230.9	19.11
9	230.3	18.13	232.2	18.62	233.4	19.52
10	230.1	19.60	231.5	20.01	232.4	20.96
11	233.3	19.95	234.4	20.18	235.0	21.30

Appendix B: Statement of Original Work

The Concordia University Doctorate of Education Program is a collaborative community of scholar-practitioners, who seek to transform society by pursuing ethically-informed, rigorously-researched, inquiry-based projects that benefit professional, institutional, and local educational contexts. Each member of the community affirms throughout their program of study, adherence to the principles and standards outlined in the Concordia University Academic Integrity Policy. This policy states the following:

Statement of academic integrity.

As a member of the Concordia University community, I will neither engage in fraudulent or unauthorized behaviors in the presentation and completion of my work, nor will I provide unauthorized assistance to others.

Explanations:

What does "fraudulent" mean?

"Fraudulent" work is any material submitted for evaluation that is falsely or improperly presented as one's own. This includes, but is not limited to texts, graphics and other multi-media files appropriated from any source, including another individual, that are intentionally presented as all or part of a candidate's final work without full and complete documentation.

What is "unauthorized" assistance?

"Unauthorized assistance" refers to any support candidates solicit in the completion of their work, that has not been either explicitly specified as appropriate by the instructor, or any assistance that is understood in the class context as inappropriate. This can include, but is not limited to:

- Use of unauthorized notes or another's work during an online test
- Use of unauthorized notes or personal assistance in an online exam setting
- Inappropriate collaboration in preparation and/or completion of a project
- Unauthorized solicitation of professional resources for the completion of the work.

Appendix B: Statement of Original Work (Continued)

I attest that:

1. I have read, understood, and complied with all aspects of the Concordia University- Portland Academic Integrity Policy during the development and writing of this dissertation.

2. Where information and/or materials from outside sources has been used in the production of this dissertation, all information and/or materials from outside sources has been properly referenced and all permissions required for use of the information and/or materials have been obtained, in accordance with research standards outlined in the *Publication Manual of The American Psychological Association*

Rhonda Gayle Stitham

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November 15, 2018

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