A COMPARISON OF THE EFFICACY AND BELIEFS OF MIDDLE SCHOOL MATH TEACHERS AND SCIENCE TEACHERS TOWARDS STEM EDUCATION

by

Kenneth Lamar Deal, Jr.

Liberty University

A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

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Philip Alsup, Ed.D., Committee Chair

Jeffery Crawford, Ed.D., Committee Member

ABSTRACT

Little research exists in the attitudes and efficacy of middle school math teachers and science teachers toward Science, Technology, Engineering, and Math (STEM) education. STEM education refers to an integrated approach to teaching math and science that incorporates problem solving, problem-based learning, and discovery rather than teaching these disciplines in isolation. Teachers' efficacy and beliefs, outcome expectancy beliefs, and the use of STEM instructional strategies may vary by discipline. Each of these aspects are important in designing professional learning to meet the teachers' needs as well as their capacity to implement integrated, problem-based learning into the classroom. Research suggests teacher efficacy and attitude has an impact on the implementation of innovative instructional practice such as those used in STEM education and on student achievement. This quantitative research study follows a causal comparative design to compare mean scores on the Teacher Efficacy and Attitude toward STEM (T-STEM) Survey among two groups of middle school teachers. The two groups are math teachers and science teachers from middle schools that are in the First District Regional Education Association in Georgia. The total sample size was 136 participants. A Mann-Whitney U test was conducted as an analysis to determine if there is a difference between the efficacy and beliefs toward STEM of middle school math teachers and science teachers. The data collected did not reflect any statistically significant differences between the personal teaching efficacy and beliefs, teacher outcome expectancy beliefs, and use of STEM instructional practices between middle school math and science teachers.

Keywords: Teacher attitudes, teacher efficacy, middle school, STEM, problem-based learning

Copyright Page

Dedication

I would like to dedicate this dissertation to my wife, Julia, and my children, Carlie, Sara Beth, and Greyson. They have provided me with support and encouragement throughout this process. They have sacrificed family time so that I could attend classes, conduct research, and write. Without a strong family and support group, none of this is possible.

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List of Abbreviations

Science, Technology, Engineering, and Math (STEM)

Teacher Efficacy and Attitudes Toward STEM (T-STEM)

Personal Teaching Efficacy and Beliefs (PTEB)

Teaching Outcomes Expectancy Beliefs (TOEB)

Statistical Package for the Social Sciences (SPSS)

CHAPTER ONE: INTRODUCTION

Overview

Current studies assessing teachers' efficacy and beliefs toward science, technology, engineering, and math (STEM) education often focus on pre-service teachers and the implementation of specific professional development programs to change teacher attitudes (Salami et al., 2016; Nowikowski, 2017; Esra & Ercan, 2016). The purpose of this study is to determine if there is a difference between the perceptions of middle school math teachers and middle school science teachers concerning efficacy and beliefs in teaching as it pertains to STEM education.

Chapter One will discuss the importance of teacher efficacy as it pertains to student achievement in the STEM disciplines of math and science as well as the increased focus on the importance of STEM education. The problem statement will be discussed, including recommendations from previous researchers. The purpose of this study will be discussed along with its significance to current literature. Finally, the research question will be introduced along with definitions for key terms associated with this study.

Background

Increased education in the areas of science, technology, engineering, and math (STEM) from preschool to postgraduate school are needed to address global economic, health, and technological concerns. STEM education is critical to economic growth and development and keeping the United States competitive in a global market (National Academy of Engineers, 2008; Marrero, Gunning, & Germain-Williams, 2014). STEM education can be defined as an integrated curriculum with key components of problem solving, discovery, and problem-based learning (STEM Georgia, 2012). The teaching of critical-thinking and problem solving skills, 21st century skills, and logical-thinking skills are important to the development of students in these STEM areas and are imbedded in The Next Generation Science Standards (NGSS) and the Common-Core State Standards (CCSS) (Douglas, 2016; Bradley, 2016). Equally important is teachers developing positive attitudes toward collaboration with other teachers, teaching beyond their subject area and changing their current instructional strategies to enrich student interests and understandings about STEM (Salami, Makela, & Miranda, 2015). Research suggests that teachers who have high self-efficacy show a better understanding of the importance of the implementation of new instructional strategies and more often collaborate with colleagues (Zee & Koomen, 2016).

The idea of teacher efficacy has its roots in social learning theory and self-efficacy theory. Social learning theory states a person's expectancy of an event or behavior occurring is based on receiving reinforcements (Rotter, 1966, Bandura 1971). In a situation where an individual perceives he or she is in control of the event and the subsequent reinforcement, the individual believes in an internal locus of control. In a situation where an individual believes that forces outside of their control affect the reinforcement or outcome of an event, the individual believes in an external locus of control (Rotter, 1966). Social learning theory did not focus a great deal on the cognitive ability of the people who were being influenced. Incorporating cognitive ability into these ideas led to the development of the self-efficacy theory in which Bandura (1977) posited that a person's behavior is determined by his efficacy expectations or the level of influence that he believes his actions can affect the outcome. These efficacy expectations are derived from people believing their behavior can lead to certain outcomes and their perseverance in successfully implementing the behavior will achieve a desired outcome (Bandura, 1977). As research in the area of self-efficacy theory expanded, self-efficacy was found to influence the activities individuals engage in, the effort and persistence he or she gives to a task, and the levels of stress a person experiences when engaging in these tasks (Schunk, 1982).

As self-efficacy theory expanded into the field of education, researchers began to look specifically at the term teacher efficacy. The concept of teacher efficacy was found to be independent of self-esteem and self-confidence, as it is specific to the task being done and reflects the teacher's belief in his or her ability to enact these tasks (Tschannen-Moran, Hoy, and Hoy, 1998; Ryan, Kuusinen, & Bedoya-Skoog, 2015). Teacher efficacy was then defined as teachers' beliefs they have the ability to affect change and influence student outcomes regardless of obstacles such as the learning environment and student background (Gibson & Dembo, 1984; Soodak & Podell, 1996). Teacher efficacy has been connected to student achievement, teacher job satisfaction, teacher burn out, and teachers' willingness to collaborate and analyze data with colleagues through many research studies (Soodak & Podell, 1996; Tschannen-Moran & Hoy, 2001).

Evidence from the following studies conducted in the area of teacher efficacy reflected the differences between the efficacy of teachers at the elementary school level versus the efficacy of teachers at the middle school and high school level. Guskey (1982) found elementary teachers were more likely to link students' lack of achievement to their ability than middle school and high school teachers. This could be contributed to differences in the make-up of these levels. For example, elementary teachers tend to teach a small group of students all day versus middle school and high school teachers who see a larger number of students for a short time period each day. This can lead to stronger teacher-student relationships in elementary school (Ryan, Kuusinen, & Bedoya-Skoog, 2015). Changes in teacher efficacy that occur when transitioning from elementary school to middle school were found to be directly related to changes in student beliefs about the difficulty of subjects and their performance (Medgley, Feldlaufer, & Eccles, 1989).

During the 1990s, interest in teacher efficacy continued to increase. The American Association for the Advancement of Science (AAAS) conducted a study known as Project 2061. As part of this project, the AAAS reported science literacy should integrate ideas for mathematics and technology along with those of the sciences. This information, along with findings from similar reports, led to the development of science benchmarks and standards that were set to reform the teaching of science to include problem-solving and student-led discovery (Haney, Czerniak, & Lumpe, 1996; Roseman, 1997). The AAAS Project 2061 also stated a student's attitude toward science is directly related to the teacher's attitude toward science and one of its goals was for students to have a positive attitude toward science (Morrell and Lederman, 1998). Around this same time, findings by the National Science Board Commission on Precollege Education in Mathematics, Science, and Technology indicated elementary school was the optimum time to expose students to key math and science concepts. Contrary to this, research found that elementary teachers typically had less confidence in their ability to teach science. This negatively affected the attitude that their students had toward science (Waters & Ginns, 2000; Howitt, 2007; Peterson & Treagut, 2014).

Math teachers also experienced a variety of shifts in theory concerning the best practices for teaching and developing mathematics understanding. The National Council of Teachers of Mathematics (NCTM) created a document that outlined curriculum standards for mathematics calling for an increase in technology integration and mathematical modeling and problem solving into the math classroom. This change also emphasized the need for increased professional development for math teachers (Center for the Study of Mathematics Curriculum, 2004; Burris, 2005). Isiksal (2010) stated a shift in the curriculum to incorporate these ideas caused some teachers to experience increased anxiety and doubt their ability to teach math effectively resulting in their use of traditional math teaching strategies in lieu of standards-based strategies. Isiksal (2010) concurred with other research showing teachers with a high sense of efficacy in their ability to teach mathematics concepts, are more likely to use innovative instructional practices, hands-on learning activities, and new approaches to teaching math content.

In order to validate these research findings, several scales have been created to evaluate the efficacy of teachers. Gibson and Dembo (1984) developed the Teacher Efficacy Scale (TES) as a measurement tool for this construct and identified self-efficacy and outcome expectancy as key factors influencing teacher efficacy. This scale applied to the teaching profession in general. It was not specific to any content area and was used for many years to assess teacher efficacy until new research indicated the need for improvement. This led to the development of the Ohio State Teacher Efficacy Scale (OSTES). The OSTES assessed a broader range of teacher competencies than the previously developed TES in an effort to better apply to teachers across subject areas and levels (Tschannen-Moran & Hoy, 2001).

Findings on teacher efficacy, along with the underperformance of students in the United States on national and international achievement measures in math and science when compared with other developed countries, emphasized the need for changes in these areas. This research fueled the importance of implementing initiatives to bring focus to an integrated approach to science, technology, engineering, and math education known as STEM (Silver & Snider, 2014; Desilver, 2017). The United States Department of Education (2015) even released a statement touting the importance of students being able to solve challenging problems, gather and evaluate evidence, and make sense of information, all skills defining the basis of STEM education. It also reported that integrating STEM fields can cultivate curiosity and passion in students to be lifelong learners and increase their math and science literacy to aid them in addressing problems encountered in their day-to-day lives (Madison & Steen, 2003; Feinstein, Allen, & Jenkins, 2013; Silver & Snider, 2014).

This integrated approach to education requires teachers who have planned and taught STEM disciplines in isolation of one another to intentionally collaborate. In addition, there must be a strategic approach to its development and implementation to be effective (Kelly & Knowles, 2016). These teachers must be open to innovative practices in STEM subjects. Research suggests that teachers with a high sense of efficacy and a positive attitude towards teaching math and science are more apt to embrace this type of change (Sehgal, Nambudiri, & Mishra, 2017). To address these concerns the Science Teacher Efficacy Belief Instrument (STEBI) and the Mathematics Teacher Efficacy Belief Instrument (MTEBI) were developed. Both of these surveys centered on pre-service, elementary teachers and their level of efficacy towards teaching math and science (Riggs & Enochs, 1989; Enochs et al., 2000).

Teacher efficacy and how it affects student achievement, motivation, and persistence has been a key concept studied in educational research for several decades. Researchers have also analyzed how teacher efficacy is different between elementary school teachers and middle school teachers, and how it can differ between subjects taught. Throughout the process of growing the knowledge base about teacher efficacy, research in the areas of math education and science education was leading to changes in standards, the expectations of students in these subject areas, and the pedagogical skills that were effective in meeting the needs of the students. From these ideas grew the STEM education initiative and the expectation these changes were being implemented in schools, even though there was no clear guidance on how this should occur.

Middle school requires transitioning students from the elementary school environment to the high school environment and is a pivotal time in engaging students and building their confidence in math and science education. This is important for them to be able to continue to grow in these areas in high school and pursue STEM opportunities in college. Researchers also demonstrated that middle school is the time when there is a major shift in student attitudes towards STEM education and this is directly related to the quality of teaching and classroom experiences (Midgley, Feldlaufer, & Eccles, 1989; Degenhart et al., 2007; Ryan, Kuusinen, & Bedoya-Skoog, 2015).

Nowikowski (2017) posits the solution to increasing the number of students choosing STEM careers “does not include a global solution that works for all contexts.” Therefore, while there is research on teacher efficacy towards math and science education, especially amongst elementary school teachers and preservice teachers, there is still a need for more research in the area of middle school education and the teaching of STEM to understand how teachers’ efficacy and beliefs compare between middle school teachers who are focused on different content areas, yet expected to teach as integrated, collaborative partners.

Problem Statement

The science, technology, engineering, and math (STEM) education movement as an integrated approach is a relatively recent initiative in education brought to the forefront of K-12 education by the adoption of the Next Generation Science Standards and the Common Core State Standards in Mathematics (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010; NGSS Lead States, 2013). Research on elementary and middle school STEM education has shown that perspectives on STEM education and approaches to STEM integration are two major issues impacting effective STEM education (English, 2017).

STEM programs are offered to some students formally as part of the school day and in others informally as a voluntary, extracurricular offering. For this reason, STEM programs cannot be assessed in traditional manners using learning outcomes or proficiency assessments (Wiebe et al., 2013). This leads to educators facing the challenge of how to effectively integrate the STEM disciplines and ensure the integrity of each of the STEM disciplines (English, 2017).

The Friday Institute for Educational Innovations Evaluation Group and the Maximizing the Impact of STEM Outreach through Data-Driven Decision Making (MISO) Project developed a survey instrument, the S-STEM survey, to measure changes in students' confidence and efficacy in STEM subjects, 21st century learning skills, and interest in STEM careers as a means to assess STEM programs regardless of how they are offered (Wiebe et al., 2013). The Friday Institute and MISO Project study found there is a need to increase the frequency of opportunities for students to engage in STEM and with STEM industries and careers (Wiebe et al., 2013).

Other studies of student engagement in STEM education reflect traditional teaching practices must be altered to incorporate standards-based STEM programs that integrate technology and use project-based and problem-based learning (Hernandez et al., 2013; Kennedy & Odell, 2014). For this to occur, teachers must be provided with proper professional learning opportunities enabling them to guide students in gaining the knowledge and skills needed to identify and address problems in STEM fields. To do so, they also need professional learning in understanding the STEM disciplines and how they relate and interacting with STEM issues in the context of real-world problems (Kennedy & Odell, 2014).

When implementing an integrated STEM program, teachers need to be collaborative, risk-takers, and innovative while focusing on student outcomes (Slavit, Nelson, & Lesseig, 2016). Teachers also need to develop positive attitudes toward changing instructional practices and teaching beyond one discipline. This can be supported through professional learning opportunities (Custer & Daughtry, 2009; Salami, Makels, & Miranda, 2015) that address the needs of teachers in each of the STEM disciplines.

These professional learning opportunities should take into consideration that teachers have differing backgrounds and approaches based on their previous experience. For this reason, professional development in STEM integration should be flexible allowing it to be translated into integrated classroom practices (Custer & Daughtry, 2009). A lack of research suggests a necessity to study what type of support is needed to facilitate cross-curricular collaboration and interdisciplinary teaching in middle school and the efficacy and beliefs of these teachers in implementing these practices (Bennett, 2016; Salami, Makela, & Miranda, 2017). This is crucial for middle school as Midgley, Feldlaufer, and Eccles (1989) posit this is the time when students' attitudes and efficacy toward math and science have been shown to be most influential. Additionally, Degenhart et al. (2007) reported that students' attitudes toward the STEM subjects becomes more negative as they enter middle school.

A key factor contributing to the students' perspectives is the teacher's efficacy and attitude toward the subject and the subsequent relationships that are built with their students (Midgley, Feldlaufer, & Eccles, 1989; Ryan, Kuusinen, & Bedoya-Skoog, 2015). Bennett (2016), in her study on elementary teacher efficacy, found that previous studies focused mainly on student perspectives toward STEM and teacher efficacy as it relates to STEM disciplines in isolation of one another. She noted further study was needed to explore teacher efficacy in regard to STEM as an integration of subjects and with students from diverse backgrounds.

Coppola, Madariaga, and Schnedeker (2015) conducted a study to assess teacher' experiences with STEM and perceived barriers to teaching engineering. In this study, the researchers determined that time, support, and lack of training were common themes that prevented engineering in the classroom. They deduced further study was needed on opinions about engineering and STEM to provide insight into the challenges such initiatives face.

Considering these findings, the problem this study will explore is the self-efficacy of middle school math and middle school science teachers toward STEM education, specifically as they pertain to personal teaching efficacy, outcome expectancy beliefs, and the use of STEM instructional practices. This study also looks to gain further insights into barriers to the integration of STEM education into middle schools.

Purpose Statement

The purpose of this causal-comparative quantitative research study is to determine if there is a difference between the perceptions of middle school math teachers and middle school science teachers concerning their teaching efficacy and beliefs, teaching outcome expectancy, and the frequency of use of STEM instructional practices as it pertains to Science, Technology, Engineering, and Math (STEM) education. This casual-comparative research approach was chosen to determine whether the independent variables of middle school math teachers and middle school science teachers differ in their efficacy and beliefs toward STEM education (Gall, Gall, & Borg, 2007).

The sample of teachers was divided by subject area (math or science) and asked to complete a survey about their efficacy and beliefs toward STEM education. The dependent variables are: personal teacher efficacy related to a specific STEM subject, teaching outcome expectancy beliefs, and use of STEM instructional practices. *Teacher Efficacy* is defined as the teacher's belief in his/her own teaching ability and the teacher's belief in the power of the teacher to reach difficult children (Protheroe, 2008). *Teacher outcome expectancy* is the degree to which the teacher believes student-learning in the specific STEM subject can be impacted by the teacher (Friday Institute for Educational Innovation, 2013). *STEM instructional practices* are defined as instructional practices that relate to investigative problem-solving skills, making predictions, observations, data collection, and "real-world" context (Friday Institute for Educational Innovation, 2013). Data will be compiled from the Teacher Efficacy and Attitudes toward STEM (T-STEM) survey to determine how teachers' responses differ based on the subject area that they teach.

Significance of the Study

This study is significant in assessing differences in middle school math and science teachers toward science, technology, engineering, and math (STEM) education. While there are many studies on teacher efficacy and beliefs and it's effects on student achievement and engagement, the studies that relate teacher efficacy and beliefs toward STEM education primarily reference pre-service teachers and elementary school teachers. There is a need to determine how teachers' efficacy and beliefs, outcome expectancy beliefs, and frequency of use of integrated STEM instruction, differ amongst teachers of different STEM subjects, particularly in the middle school where these subjects are typically taught in isolation of each other. Johnson, Peter-Burton, and Moore (2016) theorize that teachers need to be able to teach "the *Common Core State Standards*, the *Next Generation Science Standards* while infusing the *21st Century Skills Framework."* This study will provide information about the efficacy and attitudes of middle school math teachers and science teachers toward STEM, give insight into the impact of current STEM initiatives on these teachers, and identify areas of need for professional development specific to each of the teachers' discipline.

The study is significant to middle school teachers as the existing research pertains to elementary school teachers (Riggs & Enochs, 1989; Enochs et al., 2000; Bennett, 2016). The typical elementary school teacher is self-contained and teaches both math and science, the typical middle school teacher teaches these subjects in isolation. Middle schools have differing characteristics from elementary schools in terms of classroom structure and the number of students taught by each teacher. Research is needed to address the implementation and impacts of STEM for the middle school.

Additionally, this study provided insight into how teacher attitudes and beliefs are affected when the integration of math and science is not intentional and teachers must collaborate to have an integrated STEM program (Kelly & Knowles, 2016). The Common Core State Standards for Math and the Next Generation Science Standards have been adopted in many states and advocate for more project-based and problem-based learning as well as the purposeful integration of STEM subjects. When teachers are not confident in their ability to enact these changes, they tend to revert to traditional teaching measures. Since teacher confidence and openness to change has been previously linked to the teacher's efficacy, this study provides information on whether this is more likely to occur with middle school math teachers or middle school science teachers. Additionally, this study can provide information on how middle school math and science teachers' teaching efficacy and beliefs, outcome expectancy beliefs, and use of STEM instructional strategies differ in response to STEM education following the implementation of the NGSS and the CCSS (Kelly & Knowles, 2016; Pearson, 2017).

Research Questions

RQ1: Is there a difference between personal teaching efficacy and beliefs of middle school math teachers and middle school science teachers?

RQ2: Is there a difference between the teaching outcome expectancy beliefs of middle school math teachers and middle school science teachers?

RQ3: Is there a difference between the frequency of use of STEM instructional practices of middle school math teachers and middle school science teachers?

Definitions

1. *Teacher Efficacy* - the teacher's belief in his/her own teaching ability and the teacher's belief in the power of the teacher to reach difficult children (Protheroe, 2008)
2. *Science, Technology, Engineering, and Math (STEM) education* - an integrated curriculum with key components of problem solving, discovery, and problem-based learning (STEM Georgia, 2012)
3. *Teacher outcome expectancy* - the degree to which the teacher believes student-learning in the specific STEM subject can be impacted by the teacher (Friday Institute for Educational Innovation, 2013)
4. *STEM instructional practices* – instructional practices that relate to investigative problem solving skills, making predictions, observations, data collection, and "real-world" context (Friday Institute for Educational Innovation, 2013)
5. *21st Century learning* - skills such as leadership, goal setting, time management, communication, and collaborating effectively with others (Duran, Yaussy, & Yaussy, 2011; Friday Institute for Educational Innovation, 2012)

6. *Teacher leadership* - the teacher's belief that it is important to establish a safe learning environment, use multiple data point to assess and set goals for students, and empower students (Friday Institute for Educational Innovation, 2012)
7. *STEM career awareness* - the teacher's knowledge of current STEM careers, where to find resources and information for teaching about these careers, and the ability to direct students and parents to information about STEM careers (Friday Institute for Educational Innovation, 2012)

CHAPTER TWO: LITERATURE REVIEW

Overview

Chapter Two discusses the theoretical framework and literature related to teacher efficacy and attitudes toward STEM education. Studies related to the concept of teacher efficacy are reviewed. The chapter addresses math teaching practices and efficacy, science teaching practices and efficacy, and teacher efficacy as it relates to STEM education. Changes in standards for both math and science guiding these areas towards an integrated approach are discussed along with practices in public education hindering that process. The role of professional development in increasing teacher efficacy and attitudes regarding STEM education is also examined.

Conceptual or Theoretical Framework

The conceptual framework for this study is guided by Bandura's (1977) theory of self-efficacy and outcome expectancy. The integrated teaching methodology for science, technology, engineering and math know as STEM contributes to the conceptual framework as well.

Teacher Efficacy and Outcome Expectancy

The concept of teacher efficacy and outcome expectancy, as a construct of the social cognitive theory, is derived from the idea of self-efficacy; that one's behaviors and beliefs determine their confidence and persistency, and the concept of outcome expectancy; the belief that a person's actions directly influence results (Bandura, 1977). In the arena of education, teacher efficacy can be further defined as the teacher's belief in his or her ability to competently provide content specific information to students and engage students in active learning regardless of external factors (Shaukat & Iqbal, 2012).

In pursuit of validating and quantifying this theory, Rand researchers concluded that there is a positive correlation between teachers' beliefs in their ability to change student performance and improvement in student outcomes (Armor et al., 1976). These findings fueled the desire for educational researchers to further study the link between teacher efficacy and a teacher's openness and commitment to being innovative and flexible in practice, as well as its impact on teacher retention, student engagement, and student performance. Ashton (1984) posited that teachers with a high sense of efficacy feel they have a positive impact on student learning, have high expectations for student success, and take responsibility for student learning. He also noted that these teachers self-assess when students fail, plan for student learning, are confident in their ability to influence learning, and include students in goal setting and developing strategies to achieve those goals.

Teachers who are not sure of their success or believe that they will fail avoid adding more effort as failure affects their self-esteem. In contrast, teachers who believe that they will be successful set higher goals for their students and themselves, work harder to reach those goals, and are more persistent when faced with obstacles (Bandura, 1997; Ross & Bruce, 2007). Strong teacher efficacy can lead to behavioral changes in teachers that contribute to changing students' perceptions about the subject matter and increasing student efficacy (Ross & Bruce, 2007).

All of the traits reflected by teachers with a strong sense of self-efficacy and a positive outcome expectancy are ideal for increasing student learning. Early research related to teacher efficacy centered on the general concept but did not look at any subject specific indicators. The natural progression was to then look at teacher efficacy and outcome expectancy as it pertained to specific subjects as teacher efficacy is based on self-perceptions regarding particular behaviors (Giles, Byrd, & Bendolph, 2016). One such instrument is the Science Teacher Efficacy Belief Instrument (STEBI) developed to focus on the traits needed by science teachers to positively influence student engagement and growth in science (Riggs & Enoch, 1989). Similarly, the

Mathematics Teaching Efficacy Belief Instrument (MTEBI) was developed to assess these traits in mathematics teachers as well (Enoch, Smith, & Huinker, 2000).

When looking further at self-efficacy theory, a person's self-efficacy can be influenced by performance accomplishments, vicarious learning, social persuasion, and emotional arousal ("Understanding and Facilitating Self-Efficacy," 2017). For teachers, this translates into the results of the teachers' and students' hard work, experiences and observations within the classroom, how others perceive the task and performance occurring in the classroom, and the positive or negative feedback for the teacher and students resulting from the experience. These influencers then affect the outcome responses of the teacher. These include persistence in the task at hand (whether to continue moving forward or step away), continued and future performance of instructional practices and students, and response to new and innovative ideas (whether to approach them openly or avoid them) ("Understanding and Facilitating Self-Efficacy," 2017). Cerit (2013) found teachers' efficacy toward instructional strategies and student engagement has a positive correlation to their willingness to implement curriculum reforms of this type.

During the time of increased interest in teacher efficacy and outcome expectancy as it pertains to student engagement and achievement, there were shifts being made in the theories for teaching math and science. One theory receiving increased attention is Science, Technology, Engineering, and Math (STEM) education as a comprehensive, integrated approach to teaching these content areas as opposed to a more traditional, siloed approach. Saxon et al. (2011), when researching shortfalls that are affecting the current integrated STEM initiative, cited that K-12 teaching practices tend to "isolate STEM disciplines, emphasize rote memorization of STEM content, and neglect higher-order thinking skills." Even the integration of science and mathematics into curricular units was accomplished in different ways. For example, in science-focused units, students are expected to make claims, gather evidence, and justify their claims using mathematics and science. In contrast, engineering-focused units expect students to justify their claims with "design ideas and solutions, while using science and mathematics to support these claims" (Mathis, Siverling, Glancy, & Moore, 2017).

Fortunately, teacher efficacy and outcome beliefs have been shown to be malleable and can be increased (Ross & Bruce, 2007). This increase can be contributed to experiences the teachers have in which they "perceived themselves as being professionally masterful, observed teachers like themselves being successful, persuaded each other that they could teach the new curriculum, ad engaged in stress-reduction practices" (Ross & Bruce, 2007). Althauser (2015) names targeted professional learning as one concept shown to increase teacher efficacy and positively impact student achievement.

If schools hope to increase achievement and participation in the integrated STEM program, more professional learning is needed in teaching through an integrated, problem-based approach. Mathematics and Science teachers are being expected to integrate their subject areas, along with engineering and technological practices. It is important to understand how these mathematics and science teachers feel about their ability to implement these instructional strategies, particularly any differences they may have in these beliefs. This information can be used to provide targeted professional learning and has the maximum impact on increasing teacher efficacy and student achievement.

Related Literature

As researchers explore efficacy as it relates to teaching and learning, Dorman (2001) suggests efficacy and outcome are related to classroom environment. He further states it is important the context of student learning is recognized as an important factor when studying academic efficacy and outcome variables (Dorman, 2001). Other researchers concur as many studies involving teacher efficacy and outcome expectancy are subject area specific.

Mathematics Education and Efficacy

Mathematics is one of the major areas of STEM education and an area in which the United States has shown a need for growth, especially in middle school. Results from one of the largest international assessments of mathematics, the Programme for International Student Assessment (PISA), for 2015 shows students in the United States placed 38^{th} out of 72 countries in the area of mathematics. Similarly, the National Assessment of Educational Progress (NAEP) for that same year reflects a decrease in the average math scores for 8^{th} grade students for the first time in over a decade with only 33% of 8^{th} grade students scoring at the proficient or advanced level in mathematics (Desilver, 2017). Shifts in the theories for teaching mathematics from the "traditional" skills-based instructional model to an integrated, problem-based instructional model and the need for increased achievement in mathematics warrants more research. It is important to review the changes in the beliefs and expectations of teachers of mathematics.

There is a discrepancy between the beliefs and expectations needed for math teachers in the middle school to successfully prepare students and what teachers are actually doing in the classroom. For many years, mathematics instruction has seemed to be in a pattern of ever-changing expectations, ranging from "New Math" in the 1960s to the most recent Common Core State Standards (Posamentier & Krulik, 2016). Teachers' beliefs and knowledge regarding children's mathematical thinking and effective instructional practice has shown to reflect in an increase (or decrease) of student understanding and problem-solving abilities in mathematics which is a significant part of STEM education (Philipp, 2007; Jacobson, 2017).

Math instructors, when compared to those of other STEM subjects, had the most fixed mindset about who could learn math (Boaler, 2016). In general, mathematics teachers typically embrace the philosophy that the ability to learn math is innate and certain types of students "can't do math" (Drew, 2011). This fixed mindset around who can learn directly correlates to how they teach and which students are successful in their classes. Ross and Bruce (2007) cite mathematics education reform threatened teacher efficacy because it implemented unfamiliar instructional strategies, drew on content knowledge that they may not have, engaged low-ability students in abstract thinking, and incorporated classroom discussions that take "unpredictable directions."

Mathematics teachers need to have deep content knowledge, along with a mastery of teaching strategies, to effectively increase mathematics achievement. This does not seem to be true for the majority of middle school math teachers in the United states according to the 2010 Teacher Education and Development Study in Mathematics (TEDS-M) (Schmidt, Houang, & Leland, 2011). Posamentier & Krulik (2016) theorize that many teachers in the United States are not comfortable with the current mathematics curriculum due to not being adequately prepared to implement the new standards. It has thus been noted, in the United States, mathematics instructional practices have continued to be primarily focused on skills and fluency (Stigler & Hiebert, 1999; Sawchuk, 2018).

The National Council of Teachers of Mathematics (NCTM) found that there are pockets of excellence in the teaching of mathematics rather than systemic excellence. NCTM cited that the reasons for this are "too much focus on learning procedures without any connection to meaning, understanding, or the applications that require these procedures, too many students are limited by the lower expectations and narrower curricula of remedial tracks from which few ever emerge, and too many teachers of mathematics remain professionally isolated, without the benefits of collaborative structures and coaching, and with inadequate opportunities for professional development related to mathematics teaching and learning" (NCTM, 2014). A more recent series of reports from the Education Trust reported 87% of middle school math assignments incorporate only skills and fluency while fewer than a third required students to explain their reasoning using mathematical terms, and only 5% were designed to stimulate peer discussions regarding math (Sawchuk, 2018).

Part of the reason this is the case can be linked to lack of curricular coherence across states in terms of mathematics education and math teachers feeling that state assessments are not addressing the Standards of Mathematical Practice. These include being able to problem-solving and explain mathematical reasoning (Davis, Choppin, McDuffie, & Drake, 2017). Mathematics in STEM must be made clear and obvious; it cannot be assumed students will "see" the mathematics in integrated, STEM tasks (Shaughnessy, 2013). Teachers of mathematics should be confident in teaching their content skills, acknowledge what skills and concepts should be developed in the math classroom, as well as how to develop an in-depth understanding of mathematical concepts within integrated STEM tasks (Honey et al., 2014; English, 2016). Additionally, mathematical literacy is an essential element of making data-driven, evidence based decisions as it provides students with the ability to validate data that they encounter, analyze their own data, and engage in discussions concerning the solutions that they reach (English, 2016).

Hackett and Betz (1989) defined mathematics efficacy as an assessment of a person's confidence in his ability to accomplish a task or problem. They also noted this as an indicator of future math performance. Mathematics efficacy was also shown to be correlated to attitudes towards mathematics and influential in a person choosing college majors in a math related field (Hackett & Betz, 1989). Further research into teacher's efficacy in math found that this construct is linked to the teacher's effort in teaching, persistence and resilience when faced with student difficulties and the teacher's enthusiasm and commitment to teaching (Tsamir et al., 2013). However, with the reform in mathematics instruction to use teaching strategies that engage students in diverse, active learning experiences and to emphasize conceptual understanding to include science, technology, and engineering, teachers can develop an increase in anxiety. This increased anxiety can then lead to a reduction in the teacher's self-efficacy (Thomson, DiFrancesca, Carrier, & Lee, 2017). Lu and Bonner (2016) noted that although teachers understand that conceptual knowledge is key to successful math education reform, they are likely to rely on procedural knowledge when put under pressure in the classroom. This results in the teacher using traditional, teacher-centered pedagogical strategies and focusing on basic skills as opposed to student-centered, problem-based learning (Swars, Daane, & Gieson, 2006).

While there have been efforts to provide professional development for teachers in implementing new standards that incorporate more conceptual understanding, teachers report that they are less familiar with the content standards for other grade levels besides the one that they teach (Davis et al., 2017). In one study, only 57% of teachers with a high sense of efficacy in the teaching of mathematics and their ability to motivate students felt as strongly about their ability to provide effective teaching for their students (Nurlu, 2015). Therefore, math teachers must be provided opportunities to increase their knowledge of the concepts being taught and how they relate to past and future learning (Carney, Brendefur, Thiede, Hughes, & Suton, 2016). This effort will positively influence the confidence of the teachers in their ability to teach mathematical concept and lead to an increase teachers' efficacy. An increase in efficacy may then lead to an increased willingness to continue implementing innovative practices associated with STEM education reform.

Science Education and Efficacy

Similar to math education, students in the United States have not scored as well as those in other advanced countries in the area of science. Overall, the United States is ranked in the middle of all countries participating in the Programme for International Student Assessment (PISA) and ranks 19th out of the 35th members of the Organization for Economic Cooperation and Development (Desilver, 2017). Also, like mathematics education, there have been changes in the standards and expectations for science education in an effort to increase critical thinking and problem-solving skills along with student achievement.

Science education has not always been treated as an important area of study compared to mathematics and language arts. When the No Child Left Behind Act (NCLB) was implemented in 2001, its focus was on closing the achievement gap in math fluency and reading to make all students proficient in these areas by 2014 (Johnson, 2013). This, according to Johnson (2013), led to states creating assessment measures for science that were strictly recall based and only assess a small portion of the broad content standards.

During this time, researchers began to notice that students in the United States were not only underperforming in the sciences as compared with other developed nations, they were also lacking in the ability to make informed decisions regarding real-world, scientific issues. This lack of understanding of science and technology would hinder them being effective in a quickly changing technologically rich society (Singer, Hilton, & Schweingruber, 2006). Other contributing factors to the underperformance of students in the area of science has also been teachers at all levels, elementary, middle, and high school, not being properly prepared to teach the level or area of science that they are asked to, not being given adequate resources needed, and not being provided the professional development needed to implement the curricula well (Michaels, Shouse, and Schweingruber, 2008).

In 2007, the National Research Council (NRC) reported that improvements in science education in the United States were only modest after being focused on standards-based reform for 15 years. Sun You (2016) specified scholars agree science instruction should be inquiry based, focused around problematic tasks, and students' ability to explain and justify a claim. As science standards and teacher education programs have shifted into this understanding of effective instructional practices, there has been a need to measure science teachers' use of these practices. Hayes et al. (2016) realized there was not a comprehensive survey addressing Science and Engineering practices introduced by the Next Generation Science Standards (NGSS). This lead the NRC to validate a Science Instructional Practices Survey (SIPS) aligned with the inquiry-based expectations of the NGSS. While this is a valid instrument, it is an instrument isolated to the Sciences as a separate content. This is not reflective of a shift to an integrated approach to STEM education.

As a result of these findings, a collaborative effort was launched in 2010 to revise the nation's science standards in an effort to push our educators and students to reach higher levels of understanding in the sciences (Pratt, 2011). From this effort, the Next Generation Science Standards (NGSS) were created to "increase academic rigor and demand that all students apply science and engineering practices and crosscutting concepts across a range of disciplinary core ideas" (Lee, Muiller, & Januszyk, 2014). These standards meet the needs that researchers report science students in the United States need. Lee, Miller, & Januszyk (2014) also point out they require science teachers to make instructional shifts and provide resources and supports for students to be successful.

Traditional science courses in teacher preparation programs have been taught through note taking and lecture with little emphasis on integrating the sciences or the application of the concepts. This has been shown to be influential in how those teachers will teach the material (Ford et al., 2012). In order for teachers to make the shifts needed and meet the rigor requirements of the NGSS, they must have a strong sense of efficacy in the area of science.

Personal Science Teaching Efficacy (PSTE) is defined as a teacher's belief on how effective he or she will be in teaching science, while Science Teaching Outcome Expectancy (STOE) is defined as how the instruction affects the science achievement of students (Buss, 2010). Teachers' with high outcome beliefs and efficacy believe they can effectively reach students by nurturing their learning abilities and implementing effective teaching strategies (Olgan, Guner Aplaslan, & Oztekin, 2014). Senler's study on pre-service teachers' efficacy (2016) found teachers with a positive attitude towards teaching science have a higher self-efficacy in that area as well. However, this same study also found an increase in anxiety amongst teachers leading to a lack of confidence and belief in their ability to teach science (Senler, 2016).

While these studies focus on pre-service teachers' efficacy, it is important to note changing the science standards to the more rigorous NGSS may create anxiety for veteran teachers who have not been properly trained or given resources for implementation. Research studies agree teachers lack of content knowledge and professional development lead to lower confidence in teaching the science standards and can also negatively impact the attitudes and beliefs of the students that they are teaching.

Science, Technology, Engineering, and Math (STEM)

In recent years education has transitioned into a global society that is driven by innovation with an increasing dependence on the integration of all areas of science, such as engineering, mathematics, technology, and traditional sciences in the work force. Due to advancements in these areas occurring rapidly, the needs of the modern work force are changing faster than we can prepare students and are requiring students to be more adept in the areas of critical thinking and problem solving (Hernandez et al., 2014). The need for public education to better prepare students for entering this new era has been made evident by the low percentage of students performing at proficient levels in the area of math and science when using national and global achievement assessments. In turn, this created a focus on improving math and science education as well as critical thinking and problem-solving skills (Hernandez et al., 2014).

In 2010, President Obama signed the America COMPETES Act encouraging ingenuity and innovation in America and increased funding for research and development and STEM education. The goal was to "raise American students from the middle to the top of the pack and to make sure we are training the next generation of innovative thinkers and doers" (Holdren, 2011). The American Innovation and Competiveness Act was the successor to this act and passed by Congress in 2016. This Act established a STEM education Advisory Panel and the Center of Excellence. The purpose of the Advisory Panel and the Center of Excellence was to collect and distribute information to increase the participation of underrepresented populations in STEM. Additionally, the act established a group to analyze research on best practice in promoting inclusion in the STEM field and undergraduate STEM experiences (Ambrose, 2016).

This is a testament to the commitment made to grow and develop student experiences in STEM education.

In concurrence with these acts mathematics and science experts have developed new standards (the Common Core State Standards in Mathematics and the Next Generation Science Standards) to better engage students and prepare them for post-secondary education and 21st century career opportunities (Lesseig et al., 2016). Both the math and science standards focus on an integrated approach to education allowing students to learn concepts in the context of problem solving. Students apply basic understandings of concepts and theories devloping more intricate and abstract concepts. This integrated approach to the teaching of science, technology, engineering, and math is known as STEM education.

The push for an integrated approach to teaching the STEM disciplines is rooted in the idea that these subjects (science, math, technology, and engineering) should be taught in a way that simulates how students experience them in the "real-world." (STEM Task Force Report, 2014). Students should be exposed to and required to work on tasks that force them to use skills and knowledge from these multiple disciplines (Honey et al., 2014). This has been difficult to accomplish in public education as students and teachers are not necessarily comfortable with this approach to STEM education.

STEM education is not only the integration of science, technology, engineering, and math concepts, but also the development of STEM literacy. STEM literacy refers to individuals having the knowledge, attitude and skills necessary to identify problems in real-life situations and make evidence-based conclusions. It also denotes an awareness of how these STEM fields shape out cultural, material, and intellectual worlds, and a willingness to engage in STEM-related issues as a concerned and reflective citizen (Bybee, 2013). Students need to be STEM literate in order to function and thrive in a technological world (Vasquez, Sneider, & Comer, 2013). STEM literacy should weave together each of the four areas of STEM and grow as students and teachers learn more about each field and how the fields interconnect. (Vasquez, Sneider, & Comer, 2013).

Teachers must also be STEM literate and have a strong belief in their ability to teach these concepts to students in order for this to be relayed to students. According to Stephan, Pugalee, Cline, and Cline (2017), STEM literacy for teachers falls under four pillars "learning to know, learning to do, learning to live together, and learning to be." Learning to know suggests that teachers must know the content at a deeper level to apply it to situations. Learning to do implies teachers should employ inquiry-based teaching strategies and an emphasis on 21st century skills to promote active engagement in learning. Learning to live together involves teachers purposely teaching students collaborative skills and building a sense of community. Finally, learning to be is the fostering of perseverance to meet challenging goals (Stephan, Pugalee, Cline, & Cline, 2017).

In K-12 education, mathematics and science are the primary areas of focus when discussing STEM education. While most researchers agree that each area of STEM education should get equal attention as each work together to form this integrated approach, technology and engineering are given little attention. One reason for this is a push for data usage as an accountability measure for teachers, which directs a stronger focus to tested subjects (Braaten, Bradfors, Kirchgasler, & Barocas, 2017). Teachers are also less familiar with how to integrate engineering and technology into their classroom or unwilling to embrace the teaching style needed to engage students in an integrated STEM curriculum such as problem-based learning.

When incorporating technology into the classroom, teachers consider their personal use of technology and student use of the internet for research to be technology usage in the classroom. However, STEM education seeks to put the same technological tools used by professionals into the hands of the students and to guide them in using technology. The goal being that students use the technology to communicate and collaborate with each other, to support higher order thinking skills, and to create new ideas and solutions to problems.

Teachers of STEM are also expected to use instructional practices leading to inquiry and problem-based learning. Johnson et al. (2016) state that STEM education must include motivating and engaging context, engineering design challenges, standards-based mathematics and science objectives, and content taught in a student-centered manner. It must also emphasize teamwork and communication and allow for student to learn from failure. These practices should mimic the engineering design process as a way to approach a problem or task. The engineering design process is one that is used by engineers and is circular, meaning the steps can be repeated as often as needed to make improvements. The steps include asking questions to identify the need (problem), researching the problem, developing possible solutions, selecting a promising solution and building a prototype. The final steps are to test and evaluate the prototype and to improve on the design as needed (TeachEngineering, n.d.).

Another key aspect of this process is working with a team mindset and allowing students to learn how to work in a group. Skills needed in a 21st century STEM field include being able to lead and encourage others, respect each other's differences and to help their peers, adapt to the group they are working with, and to work well with people from diverse backgrounds.

Middle School and STEM Education

The middle school, traditionally grades 6-8, is a critical time in a child's education. Currently, there are initiatives to have students complete college and career readiness plans in middle school so that they can begin to anticipate career pathways in high school. Students are also transitioning from a concrete learning mindset to more abstract concepts and gaining more independence in their education. Therefore, it is critical students are given opportunities to explore as many areas of interest as they can and develop an understanding of connections between what they are studying and the outside world.

A study by Blotnicky, Franz-Odendal, French, and Joy (2017) examined a correlation between STEM career knowledge, mathematics self-efficacy, and career interests and activities on the likelihood that middle school students would pursue a STEM career. Students were given different scales to evaluate each area. They received a STEM career knowledge (SCK) score, a Mathematics Self-Efficacy (MSE) score, a ranking of career activities and interests from Holland's Theory of Career Choice and Development, and Likert scale survey results to determine their likelihood of pursuing a STEM career in the future (Blotnicky et al, 2017). Outcomes from these scales and surveys found even by the end of middle school, students had a low SCK score even though they were entering high school and expected to begin making pathway choices for future education. Blotnicky et al (2017), also found students who had a higher self-efficacy in math tended to be more knowledgeable about the requirements of STEM related careers and were more interested in these careers. Ultimately, knowledge of STEM careers and self-efficacy are significant factors affecting the pursuit of STEM careers. Students in middle school still have a limited knowledge of STEM careers. This can be correlated to a decrease in students' interesting STEM activities in high school which affects the number of graduating high school students who pursue a STEM career (Blotnicky et al., 2017). Therefore, it is important that students are more informed of the STEM careers and their education requirements earlier in their schooling.

From this study, research gleaned alternative ways of teaching and evaluating STEM courses should be considered. The researchers also suggest a greater emphasis be placed on authentic means of teaching and evaluating STEM content in a way that involves collaboration, problem solving, and meaningfully engaging STEM activities (Blotnicky et al., 2017). This is especially crucial for increasing STEM career knowledge and requirements while maintaining student interest beyond middle school. Changes must begin with teachers. Teachers must increase their outcomes expectancies for students to increase their efficacy. Teachers must create integrated STEM units that increase student interest and increase their knowledge of STEM careers.

Another hindrance to an integrated approach to STEM education is that the subjects associated with STEM are being taught in a primarily isolated environment. The curriculum is dominated by more procedural and fact based knowledge rather than real-world problems in which students apply a deep understanding of key concepts (Masters, 2016). Departmental agendas, content standards, and end-of-year assessments are some of the structures that perpetuate this isolation (Kelly & Knowles, 2016). These approaches are not reflective of the "natural way" that these disciplines are connected in the world when the nature of overcoming challenges are increasingly cross-curricular (English, 2016; Master, 2016). While this is understood by many educators, it does not address the fact there needs to be an effective way to integrate these subjects without compromising the integrity of each one (English, 2016).

While STEM stands for science, technology, engineering, and math, there is concern among researchers each of these areas is not receiving equitable representation. References have been made implying the role of STEM is to only expand science education and science literacy in elementary, middle, and high school (English, 2016). Mathematics comes in second to science in importance whereas it should be considered as equal. Mathematics is an underlying foundation of the other areas and mathematical literacy is as important as scientific literacy in preparing students for 21st century careers. English (2016) also suggests engineering education is severely neglected in elementary and middle school and tends to be the "silent member of the STEM acronym."

Wang & Nam (2015) pointed out that engineering in the real-world is not performed in isolation, but is a combination of science, math, and technology. In schools, engineering is a link that can be used to connect these three disciplines as well. Engineering can act to turn abstract concepts in mathematics and science into concrete re-life applications (Wang & Nam, 2015). English (2016) posits that not including engineering in the STEM process is a strong impediment to the advancement of STEM programs. Engineering education in STEM programs in the elementary and middle schools needs greater recognition. In a shift in this direction, the Next Generation Science Standards do include engineering practices as part of the science curriculum, however the next step is attaining teacher buy in and acceptance of these standards (English, 2016).

Another road block to engineering integration is many science and mathematics teachers lack the engineering background knowledge needed to implement concepts into the curriculum. This lack of knowledge negatively affects the teachers' attitude and self-efficacy towards teaching engineering concepts (Wang & Nam, 2015).

In the area of technology education, an increased interest in coding has led to an increase in the area of technology as it relates to STEM education. It is important that computer coding and the associated computational thinking are linked back to mathematics in order for students to build an understanding of the mathematical background of coding (English, 2016). There are many new programs designed to teach coding to elementary and middles school students, making it more accessible to all learners.

The success of these initiative still depends on the implementation of a STEM program with fidelity. This includes teachers having confidence in their ability to implement the program and confidence that the program will have a positive impact on student outcomes.

Teacher Efficacy and STEM Education

STEM education as an integrated approach to teaching science, technology, engineering and mathematics requires educators to be well versed in the content they are teaching. They must also be comfortable in the roll of a facilitator of student learning, and flexible in their teaching practices so they are open to new ideas. Research establishes teachers with a high self-efficacy have a positive attitude towards using innovative practices and are more likely to implement new instructional strategies. These teachers are also more likely to implement new programs and change their behaviors to improve effectiveness in the classroom while exhibiting persistence (Jerald, 2007; Lakshmanan et al., 2011).

One focus of research has been on preservice elementary education teachers and their self-efficacy in teaching science and mathematics. Buss (2010) found preservice elementary teachers had lower efficacy for teaching science and mathematics than for other content areas. When this was the case, the teachers spent significantly less time on science instruction and did not teach science using the inquiry skills and STEM teaching practices, even though these have been shown to engage students in science education (Waters & Ginn, 2000; Mansfield & Woods-McConney, 2012). In contrast, Isiksal (2010) stated pre-service elementary teachers with a high self-efficacy in mathematic were more likely to use new approaches to teaching, hands-on teaching methods, and innovative mathematics teaching. These results are significant because elementary school teachers typically teach all subject areas and build the foundations for inquiry based learning, an interest in math and science, and student engagement.

Harnett (2016) found middle school and high school math and science teachers, despite the research supporting STEM education and the call to increase STEM opportunities for students, are still teaching their subjects in isolation of one another. This is due to the way our schools are set up to teach these classes separate of one another and continue to require standardized testing for all students. Weis, et al. (2015) investigated two high schools implementing an integrated STEM program and offering higher level math and science courses. In their research, Weis et al. (2015) noted these high schools were unsuccessful and blamed this, in part, on weak student achievement, graduation rates, and accountability measures. Honey, Pearson, & Schweingruber (2014) found when assessing the effectiveness of STEM education, particularly in middle and high school, academic areas are still assessed separately and using standardized measures. It is easy for teachers to fall back into routine processes without training, confidence, and a high sense of self-efficacy and outcome expectancy.

Vasquez, Sneider, and Comer (2013) stated teachers have not been trained in a best practice for integrating the disciplines. In middle and high school, this involves multiple teachers collaborating as these subjects tend to be taught by separate teachers. They also tend to feel overwhelmed about where to begin this process. Vasquez, Sneider, and Comer (2013) present four levels of integration to provide a progression from minimal to full integration.

These levels are disciplinary, multidisciplinary, interdisciplinary, and transdisciplinary. The disciplinary level refers to students learning the content and skills of each subject separately. Multidisciplinary is defined as skills of each subject being taught separately but under a common theme. At the interdisciplinary level, students learn concepts and skills from two or more subjects that are closely linked. Finally, transdisciplinary refers to students applying knowledge and skills from two or more subjects to undertake real-world problems.

While these integration models provide scaffolding for the implementation of STEM disciplines, there is also inequitable representations of each of the disciplines concerning the impact an integrated approach may have. English (2016) noted during a 2014 STEM conference in Vancouver the distributions of presentations by subject area were: 45% science, 12% technology, 9% engineering, 16% mathematics, and 18% other. This is further implication that STEM education must break away from being seen primarily as problem-based science education.

As curriculum has been updated, each of the STEM disciplines reflect a form of problem-solving and critical thinking practices that are expected to be integrated into their standards. In mathematics, the Common Core State Standards (CCSS) (2011) refer to these as the Standards of Mathematical Practice and the Next Generation Science Standards (NGSS) refer to these as Science and Engineering Practices (Honey et al., 2014; Vasquez, Comer, & Villegas, 2017). These practices imply integration of the STEM disciplines as an expectation through defining problems, developing solutions, interpreting data, abstract and quantitative reasoning and developing viable arguments from evidence.

Professional Learning and Teacher Efficacy

Lotter, et al. (2016) in a study of increasing teacher efficacy reiterates that teachers' efficacy about their ability to teach science influences the effort and skill they use to implement new instructional strategies such as those outlined in the Next Generation Science Standards (NGSS). These strategies are the same ones outlining current STEM initiatives. Lotter et al. (2016) did find teachers who participated in an inquiry professional development model did increase their self-efficacy. Lesseig et al. (2016) related when teachers saw increases in student attainment of STEM practices, motivation and engagement, they were more likely to continue with STEM design challenges as part of a professional development session. Green and Kent (2016) also noted teachers must be immersed in their academic subjects and able to develop advanced thinking and problem-solving skills in their students to support high standards of learning. This is achieved through professional learning opportunities.

The Golden LEAF STEM Initiative in North Carolina was enacted in 2012 with the purpose of improving STEM teaching and learning for rural, economically disadvantages, an/or tobacco dependent students in grades 4 through 9 (Faber et al., 2013). As part of the evaluation process, implementing teachers were surveyed using the T-STEM instrument. It was found teachers were confident in their own teaching ability, but less than half felt their efforts made a difference in student outcomes. Additionally, teachers noted many subjects still operated separate from one another rather than being integrated (Faber et al, 2013).

After implementing targeted professional learning, the Golden LEAF STEM Initiative found in the second year there were significant improvements. The researchers cited that student engagement in STEM was higher, students' problem-solving skills increased, and students had better developed collaboration skills (Faber et al, 2013). In the area of teaching, researchers found teachers increased their use of hand-on, inquiry based instruction and school communities were more committed to STEM education. However, the integration of STEM subjects and the frequency of meaningful collaboration and professional learning opportunities remained the same (Faber et al, 2013).

The Golden LEAF STEM Initiative, targeted at middle school STEM education, made several recommendations to support the continued growth of STEM integration. These include continuing to implement hands-on, problem-based STEM curricula while increasing the rigor of instruction and continuing to provide time for STEM teachers to collaborate within departments and grade-levels to support cross-curricular integration. Along with this, teachers need to have a safe place to discuss differing outcome expectancies, philosophies and beliefs (Faber et al, 2013).

The Golden LEAF STEM initiative further recommended school districts increase professional learning opportunities incorporating content-specific, hands-on, and grade-level specific providing “immediate classroom solutions” (Faber et al, 2013). Kelly and Knowles (2016) found that teachers need professional learning providing a strong conceptual framework for an integrated approach to STEM and building teacher confidence in that approach. In addition, they cite further research is needed in effective methodologies and strategies for the integration of STEM education (Kelly & Knowles, 2016).

The studies previously referenced reveal there are a variety of implementation strategies for integrated approaches to STEM education in schools. These strategies require teachers have the background knowledge and confidence in their teaching ability to deliver content to their students. Studies have shown confidence leads to an increase in efficacy. Professional learning opportunities for math and science teachers in an integrated STEM environment must be designed with each teacher group's unique background in mind and the understanding teachers have the added pressure of standardized testing to overcome (Avery & Reeve, 2013).

Post-Secondary Education

While professional development provides an avenue for in-service teachers to grow their self-efficacy, post-secondary educational institutions are also looking to provide opportunities for pre-service teachers to obtain the skills necessary to teach rigorous content in an integrated STEM model. This follows the model as outlined in the Common Core State Standards for Mathematics (CCSSM) and the Next Generation Science Standards (NGSS). Mulnix and Vandergrift (2017) reported in 2012, the American Association for the Advancement of Science (AAAS) along with support from several other institutions, developed a plan for improving undergraduate education. This plan is not well known because it requires rethinking the way university professors teach. It requires these professors collaborate both inside and outside of their department which is not typically done at this level (Mulnix & Vandergrift, 2017).

Aside from revamping the way STEM content is taught, there are also changes to be made in teacher preparation programs so teachers of math and science are better prepared for the new standards and innovative classroom practices they are being called upon to implement. This is important to building capacity in K-12 educators to address the need for top STEM students to go into the STEM pipeline and choose to teach STEM courses. Research suggests the United States is not producing enough STEM graduates to meet future job demands. This is directly related to the number of high school students choosing to pursue STEM tracks in college (Sahin, Elmekci, & Waxman, 2017).

Aydeniz and Ozdilek (2016) found pre-service teachers' self-efficacy was increased when there was a focus on their understanding of argumentation as a scientific practice and a teaching tool. In turn, teachers must engage in constructing, evaluating and teaching through argumentation. Another study reports student teachers have a stronger sense of self-efficacy when they were provided specific skill integration into the student teaching experience and when their supervising teacher was determined to have strong content and pedagogical knowledge. This then translated into the need to continue professional learning opportunities for in-service teachers as well (Han, Shin, & Ko, 2017).

Summary

Teacher Efficacy and Beliefs about Science, Technology, Engineering, and Math (STEM) instruction is a strong indicator of whether or not it will be successfully implemented in schools. Research supports the transition of math instruction from traditional, skills-based instruction to problem-based learning. Additionally, research supports teaching science through inquiry, and the importance that technology and engineering practices be intertwined with math and science. Finally, research shows the positive effects that professional development can have on teachers implementing innovative practices when they have high self-efficacy, yet there is still a need to understand what these teachers need to be successful.

Middle school is a pivotal time that bridges the gap between learning in elementary school and high school where students begin to fully implement the aspects of STEM education as it applies to post-secondary education and the workforce. Capraro and Nite (2014) believe middle school students need 21st century skills as provided in STEM education to compete in a global world. They also relay middle school STEM curricula can lead to higher level math, science, and engineering courses in secondary and post-secondary education. Even with this knowledge, American students' success in math and science begins to waiver in middle school and continues to decrease through high school (Drew, 2011).

Multiple studies provide information on programs for pre-service teachers focusing on increasing content knowledge and confidence in teaching ability to ensure a high level of teacher efficacy. Studies provide insight into math and science instruction at the elementary level and the relationship between student achievement and teacher efficacy. Research still needs to occur with teachers at the middle school level to understand how math teachers and science teachers, who teach subject-specific courses, feel regarding their ability to be successful in reaching student through the use of STEM instructional practices, 21^{st} century learning, and technology use.

CHAPTER THREE: METHODS

Overview

This study examined the difference between the beliefs and efficacy of middle school math teachers and science teachers toward STEM. The *Teacher Efficacy and Attitude toward STEM* (T-STEM) survey was used to collect data. Chapter Three contains information on the design of the study, the research questions, the null hypothesis, the participants and setting, the instrumentation, the procedures, and the data analysis for this study.

Design

This quantitative research study followed a causal-comparative design to compare mean scores on the *Teacher Efficacy and Attitude toward STEM* (T-STEM) survey among middle school math teachers and science teachers. The causal-comparison design was appropriate for this study because it sought to compare the teachers' efficacy and beliefs toward STEM education between middle school math teachers and middle school science teachers (Gall, Gall, & Borg, 2007). This study may also be referred to as *ex post facto* as it is not introducing any experimental elements, but instead looked to discover natural differences occurring between teachers who are trained in the teaching of differing subject matter and how that may affect efficacy and beliefs toward STEM education (Gall, Gall, & Borg, 2007).

Judson (2017) in his study on how math and science teachers address different course levels found math and science teachers differ in their beliefs concerning student learning as it pertains to overcoming deficiencies, outcome expectations based on student achievement levels, and autonomy to set goals and vary content. Additionally, middle schools continue to teach math and science as separate disciplines which creates a barrier to collaboration and STEM integration (Ruggirello & Balcerzak, 2013). The independent variable in this study was middle school teachers leveled by subject area - math or science, and the dependent variable was teacher efficacy and beliefs toward STEM as measured by the *Teacher Efficacy and Attitudes Toward STEM* (T-STEM) survey.

Research Questions

RQ1: Is there a difference between personal teaching efficacy and beliefs of middle school math teachers and middle school science teachers?

RQ2: Is there a difference between the teaching outcome expectancy beliefs of middle school math teachers and middle school science teachers?

RQ3: Is there a difference between the frequency of use of STEM instructional practices of middle school math teachers and middle school science teachers?

Hypotheses

The null hypotheses for this study are:

$H_0$1: There is no statistically significant difference between personal teaching efficacy and beliefs of middle school math teachers and middle school science teachers as shown by the *Teacher Efficacy and Attitudes Toward STEM* (T-STEM) survey.

$H_0$2: There is no statistically significant difference between the teaching outcome expectancy beliefs of middle school math teachers and middle school science teachers as shown by the *Teacher Efficacy and Attitudes Toward STEM* (T-STEM) survey.

$H_0$3: There is no statistically significant difference between the frequency of use of STEM instructional practices of middle school math teachers and middle school science teachers as shown by the *Teacher Efficacy and Attitudes Toward STEM* (T-STEM) survey.

Participants and Setting

The participants for the study were drawn from public middle school math and science teachers located in a southeastern state of the United States. The schools from which the teachers were sampled are members of a regional education agency made up of 18 school districts in the area. County A has approximately 9,793 students, County B has approximately 10,975 students, County C has approximately 11,079 students, and County D has approximately 12,164 students. County A has 2 middle schools with a total of 21 math teachers and 21 science teachers, County B has 4 middle schools with 28 math teachers and 27 science teachers, County C has 3 middle schools with 29 math teachers and 27 science teachers, and County D has 4 middle schools with 28 math teachers and 27 science teachers.

A convenience sample of 93 middle school math and 43 middle school science teachers were chosen for this study. Once permission was obtained from each school district's Superintendent, an email was sent to each math teacher and each science teacher at the middle schools in the district. The email explained the purpose of the study and how the information would be collected from those who opted to participate. All respondents were selected to be part of the sample unless the teacher taught both math and science; those teachers were excluded from the sample. The number of participants sampled will exceed the required minimum for a medium effect size. According to Gall et al. (2007), 56 teachers in each group is the required minimum for a medium effect size with statistical power of .7 at the .05 alpha level meaning the total sample size needed is 112 teachers. The make-up of the sample teacher population is shown in the tables below. Table 1 and Table 2 display the gender and race/ethnicity of the sample population, Table 3 displays the grade level and subject area taught by the sample teachers, and Table 4 displays the highest degree earned by the teachers in the sample population.

Table 1

Sample Gender

Gender	Sample
Male	30
Female	106

Table 2

Sample Race/Ethnicity

Race/Ethnicity	Sample
White	114
Black/African American	22

Table 3

Grade Level and Subject Area Taught

Grade	Math Teachers	Science Teachers	Total
6	27	8	35
7	23	22	45
8	22	13	35
6,7,8	21	0	21

Table 4

Highest Degree Earned

Degree	Sample
Bachelor’s Degree	39
Master’s Degree	52
Educational Specialist	33
Doctorate	12

Math teachers consisted of 27 6th grade teachers, 32 7th grade teachers, and 22 8th grade teachers. There were 21 teachers who teach all three of these grades (6th, 7th, and 8th). The make-up of the math teachers by gender and race/ethnicity is displayed in Table 5 and Table 6. The highest degree earned by the math teachers is displayed in table 7.

Table 5

Math Teacher Gender

Gender	Sample
Male	25
Female	68

Table 6

Math Teacher Race/Ethnicity

Race/Ethnicity	Sample
White	85
Black/African American	8

Table 7

Highest Degree Earned by Math Teachers

Degree	Sample
Bachelor’s Degree	15
Master’s Degree	36
Educational Specialist	30
Doctorate	12

Science teachers consisted of 8 6th grade teachers, 22 7th grade teachers, and 13 8th grade teachers. The make-up of the science teachers by gender and race/ethnicity is displayed in Table 8 and Table 9. The highest degree earned by the science teachers is displayed in table 10.

Table 8

Science Teacher Gender

Gender	Sample
Male	5
Female	38

Table 9

Science Teacher Race/Ethnicity

Race/Ethnicity	Sample
White	29
Black/African American	14

Table 10

Highest Degree Earned by Science Teachers

Degree	Sample
Bachelor's Degree	24
Master's Degree	16
Educational Specialist	3
Doctorate	00

This study took place in the spring semester of the 2018-2019 school year. Math teachers in this study teach students enrolled in grades 6, 7, and 8 and follow the Georgia Standards of Excellence. The Georgia Standards of Excellence for middle school math place an emphasis on representation, problem solving, reasoning, connections, and communication focusing on Number Sense, Expressions and Equations, Geometry, and Statistics and Probability (Georgia Standards of Excellence, 2016). Science teachers in this study teach students enrolled in grades 6, 7, and 8 and teach using the Georgia Standards of Excellence. Middle school science in

Georgia is divided by grade level, with 6th grade teaching Earth Science, 7th grade teaching Life Science, and 8th grade teaching Physical Science (Georgia Standards of Excellence, 2016). Table 11 and Table 12 display the race/ethnicity and student subgroup data for County A, Table 13 and Table 14 display the race/ethnicity and student subgroup data for County B, Table 15 and Table 16 display the race/ethnicity and student subgroup data for County C, and Table 17 and Table 18 display the race/ethnicity and student subgroup data for County D.

Table 11

Race/Ethnicity for County A

Race/Ethnicity	Number of Students
American Indian/Alaskan	49
Asian/Pacific Islander	153
Black	2,287
Hispanic	688
Multi-Racial	650
White	5.966

Table 12

Student Subgroup Data for County A

Subgroup	Number of Students
Male	5,012
Female	4,781
Economically Disadvantaged	5,166
Not Economically Disadvantaged	4,627
Students With Disability	1,253
Students Without Disability	8,540

Table 13

Race/Ethnicity for County B

Race/Ethnicity	Number of Students
American Indian/Alaskan	26
Asian/Pacific Islander	181
Black	4,269
Hispanic	659
Multi-Racial	388
White	5,452

Table 14

Student Subgroup Data for County B

Subgroup	Number of Students
Male	5,658
Female	5,371
Economically Disadvantaged	7,139
Not Economically Disadvantaged	3,836
Students With Disability	1,547
Students Without Disability	9,428

Table 15

Race/Ethnicity for County C

Race/Ethnicity	Number of Students
American Indian/Alaskan	33
Asian/Pacific Islander	217
Black	5,703
Hispanic	1,368
Multi-Racial	861
White	2,897

Table 16

Student Subgroup Data for County C

Subgroup	Number of Students
Male	5,618
Female	5,461
Economically Disadvantaged	7,235
Not Economically Disadvantaged	3,844
Students With Disability	1,368
Students Without Disability	9,711

Table 17

Race/Ethnicity for County D

Race/Ethnicity	Number of Students
American Indian/Alaskan	10
Asian/Pacific Islander	115
Black	1,879
Hispanic	751
Multi-Racial	547
White	8,862

Table 18

Student Subgroup Data for County D

Subgroup	Number of Students
Male	6,237
Female	5,927
Economically Disadvantaged	5,137
Not Economically Disadvantaged	7,027
Students With Disability	2,157
Students Without Disability	10,007

Instrumentation

The *Teacher Efficacy and Attitudes toward STEM* (T-STEM) survey was used to measure teacher efficacy and beliefs (Friday Institute of Educational Innovation, 2012). The purpose of the T-STEM survey was to gather information on "how confident teachers are about teaching STEM-related content, 21st century skills, and technology use in the classroom" (Friday Institute for Educational Innovation, 2012). This instrument was developed by the Friday Institute for Educational Innovation (2012) along with North Carolina State University as part of the Maximizing the Impact of STEM Outreach Project. When developing the T-STEM survey the Friday Institute of Educational Innovation used information from the Science Teaching Efficacy Belief Instrument (Riggs & Enoch, 1990), the Student Technology Needs Assessment (SERVE Center, 2005), the Student Learning Conditions Survey (Friday Institute for Educational Innovation, 2011), and the North Carolina Department of Public Instruction professional standards (2012). Bennett (2016) used the Teaching Efficacy and Beliefs and Outcome

Expectancy Beliefs constructs of the T-Stem survey to study teacher sense of self-efficacy with regard to teaching integrated STEM in the elementary school. Bennett (2016) compared the responses of teachers at a Title I school to those at a non-Title I school. While other studies on teacher perceptions toward STEM found there was teacher interest to teach STEM but lack of time and training, along with the traditional separation of subjects into specific disciplines in middle and high school, impeded effectively implementing an integrated STEM program (Coppola, Madariaga, & Schnedeker, 2015; Ruggirello & Balcerzak, 2013).

The T-STEM consists of three validated forms, one form for elementary teachers, one form for math teachers, and one form for science teachers. The math and science teacher surveys, which are identical with only the specific subject area referenced in the survey items changing, were used (Friday Institute of Educational Innovation, 2012). A comparison chart was created by the researcher as further evidence of the analogous nature of the two surveys. See Appendix A for the comparison chart.

For this study, the T-STEM was given electronically using Google forms and was anticipated to take approximately 15 minutes to complete. While the entire T-STEM survey consists of seven subscales, only the subscales of Personal Teaching Efficacy and Beliefs (PTEB), Teaching Outcomes Expectancy Beliefs (TOEB), and STEM Instruction were used as each subscale has been independently assessed for validity and reliability. All statements were evaluated using a 5 point Likert scale where 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, and 5 = strongly agree. Table 19 displays a breakdown of each of these subscales in terms of total items and score ranges.

Table 19

T-Stem Subscales

Subscale	Number of Items	Total Score Range
PTEB	11	11-55
TOEB	9	9-45
STEM Instruction	14	14-70

Note. PTEB = Personal Teaching Efficacy and Beliefs; TOEB = Teaching Outcome Expectancy Beliefs

The T-STEM Survey was not validated as a composite score, only at the subscale level. The authors of the survey discussed these subscales as themes that can be compared amongst groups. In each subscale, the higher the score the stronger the teacher's belief in that area. For example, on the TOEB the higher the score the more the teacher believes student learning is impacted by his or her actions (Friday Institute of Educational Innovation, 2012). Table 20 displays the construct reliability for each of the forms of the T-STEM survey.

Table 20

T-STEM Survey Reliability

Construct	Science	Math
Personal Teaching Efficacy and Beliefs	.908	.943
Teaching Outcome Expectancy Beliefs	.814	.849
STEM Instruction	.934	.929

Permission was given by the Friday Institute to use the survey for educational, non-commercial purposes either “as is” or modified as long as the original source is cited. See Appendix C.

Procedures

The researcher received conditional approval from the Institutional Review Board (IRB) pending documented approval from each school district in which the study was being conducted. The researcher then sent an email to the Superintendents of each of the school districts being used for the study requesting permission to conduct the survey in the district with math teachers and science teachers. The email included an explanation of the study being conducted. Once permission to conduct the survey was received via an email response from the superintendents of each district, Institutional Review Board (IRB) permission to conduct the survey was obtained. In order to keep the data collected secure and private, respondents were only identified by demographic data along with grade level and subject area taught. There was no personally identifying data collected.

Following IRB approval, an email was sent to the principal (and assistant principal(s)) of each of the middle schools explaining the purpose of the T-STEM survey along with an explanation of the study being done. It was requested they forward the survey to math teachers and science teachers in their school. The email forwarded to teachers instructed the recipient to click on the link provided if they wished to participate in the survey. Once the recipients clicked on the link provided in the email, they were redirected to the survey cover page where the purpose of the survey was explained to the participants along with a consent statement that instructed them to click yes or no to indicate their response. Recipients who selected no were redirected to a screen that provided a thank you statement. Recipients who clicked yes were redirected to the demographics page of the instrument. Once the recipients completed the demographics page, they clicked next and began the T-STEM survey instrument.

At the end of a two-week period, the researcher had not received the minimum number of responses needed (56 math teachers and 56 science teachers) thus a follow up email was sent to the same middle school principals. The email was identical to the first email sent with a follow up message encouraging principals to forward the survey to their math teachers and science teachers. During this process, many school districts' email system would tag the survey as originating outside of the school district which contributed to confusion on the part of the administrators being asked to forward the survey. After an additional two-week period, the minimum number of responses had not been received and the researcher began to email the math and science teachers in each school district directly. This email was identical to those sent to the school principals and encouraged participation. Once the minimum number of responses was obtained, the data was entered in SPSS software.

Data Analysis

The study involved conducting an independent-samples t-test to derive a statistical analysis for each dependent variable to determine if there is a difference between the mean scores of middle school teachers who teach math as compared to those who teach science (independent variable) in the areas of teacher efficacy and beliefs, teacher outcome expectancy beliefs, and the use of STEM instructional practices (dependent variables). The t-test is appropriate for determining whether the two groups differ in their mean score for each dependent variable (Gall, Gall, & Borg, 2007). Data screening was conducted prior to the analysis regarding data inconsistencies, outliers, and normality (Green & Salkind, 2017). A box and whisker plot was used to check for outliers for the scores on each of the subscales. Normality for each of the dependent variables was examined using a Kolmogorov-Smirnov test. The

Kolmogorov-Smirnov test was appropriate given the sample size was greater than fifty. The results of the Kolmogorov-Smirnov showed the assumption of normality was not met. An assumption of homogeneity of variance was examined using Levene's Test for Equality of Variances (Laerd Statistics, 2015) and this was also found to be violated.

The data screening process revealed the data did not meet the assumption of normality and the homogeneity of variance was also violated. Thus the researcher decided to use a Mann-Whitney U test. The Mann-Whitney U test is an alternative to the independent samples t-test and is recommended when the data is not normally distributed and/or violates the homogeneity variance (Green & Salkind, 2011; Laerd Statistic, 2015).

CHAPTER FOUR: FINDINGS

Overview

The purpose of this quantitative casual-comparative study was to compare the beliefs and efficacy of middle school math teachers and science teachers as it relates to Science, Technology, Engineering, and Math (STEM) education. The study involved math and science teachers taking the *Teacher Efficacy and Attitudes Toward STEM* (T-STEM) survey and answering questions in the areas of personal teaching efficacy and beliefs, teaching outcome expectancy belief, and the use of STEM instructional practices.

The teachers in this study included: (1) middle school math teachers who teach sixth, seventh, or eight grade; (2) middle school science teachers who teach sixth, seventh, or eighth grade; (3) middle school math teachers who teach a combination of sixth, seventh, and eighth grades; and (4) middle school science teachers who teach a combination of sixth, seventh, and eighth grades. This chapter describes the results of the data collected and contains the research questions, null hypothesis, and descriptive statistics used to compare the efficacy and beliefs of teachers towards STEM education based on the content area they teach.

Research Question(s)

RQ1: Is there a difference between personal teaching efficacy and beliefs of middle school math teachers and middle school science teachers?

RQ2: Is there a difference between the teaching outcome expectancy beliefs of middle school math teachers and middle school science teachers?

RQ3: Is there a difference between the frequency of use of STEM instructional practices of middle school math teachers and middle school science teachers?

Hypothesis(es)

$H_0$1: There is no statistically significant difference between personal teaching efficacy and beliefs of middle school math teachers and middle school science teachers as shown by the *Teacher Efficacy and Attitudes Toward STEM* (T-STEM) survey.

$H_0$2: There is no statistically significant difference between the teaching outcome expectancy beliefs of middle school math teachers and middle school science teachers as shown by the *Teacher Efficacy and Attitudes Toward STEM* (T-STEM) survey.

$H_0$3: There is no statistically significant difference between the frequency of use of STEM instructional practices of middle school math teachers and middle school science teachers as shown by the *Teacher Efficacy and Attitudes Toward STEM* (T-STEM) survey.

Descriptive Statistics

A Google form was used to conduct the survey and collect the results. The survey data was downloaded into an Excel spreadsheet to begin data screening. The downloaded data listed the survey responses for each participant in the form of words related to the scale completed for each question. The Personal Teaching Efficacy and Beliefs (PTEB) and Teaching Outcomes Expectancy Beliefs (TOEB) subscales were in the format strongly disagree, disagree, neither agree nor disagree, agree, strongly agree. The STEM instruction subscale was in the format never, occasionally, about half of the time, usually, and every time. The responses were then converted to a numerical scale. A mean response value was then calculated for each participant for each of the subscales. The mean values were uploaded into IBM SPSS Statistics 26 so that data analysis and statistical testing could be completed. The conversion scale is shown in Table 21.

Table 21

Conversion Table for Rating Scales

Response	**Numeric Equivalent**
Strongly Disagree/Never	1
Disagree/Occasionally	2
Neither Agree nor Disagree/About Half of the Time	3
Agree/Usually	4
Strongly Agree/Every time	5

Participants were placed into groups coinciding with the subject area they teach at the middle school level. This was determined at the beginning of the survey in the demographic's sections. Teachers had to choose whether they were a math teacher or a science teacher. Based on the teacher's response, he or she was directed to either the *Teacher Efficacy and Attitudes Toward STEM* (T-STEM) survey for mathematics teachers or the *Teacher Efficacy and Attitudes Toward STEM* (T-STEM) survey for science teachers. These two surveys are identical with only the specific subject area referenced in the survey items changing.

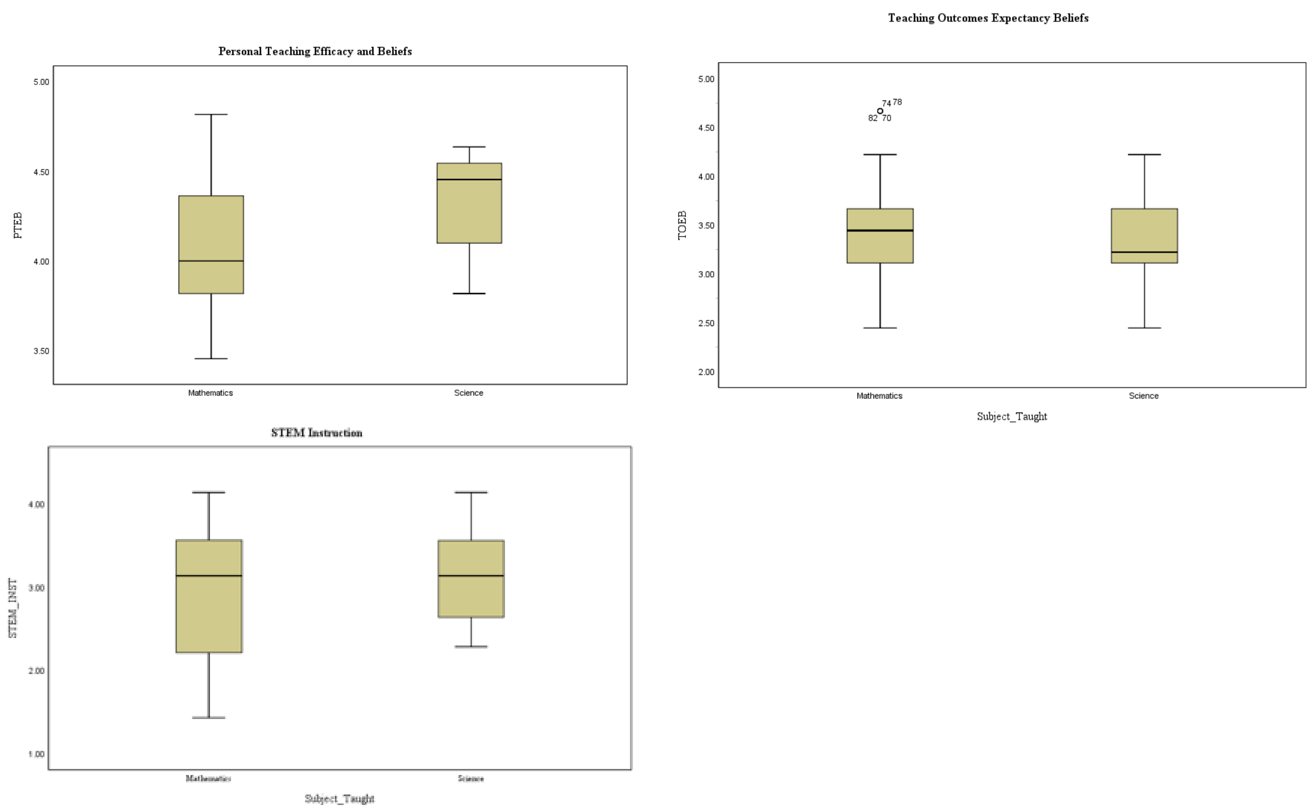
Teachers who indicated they currently teach mathematics in grades 6, 7, or 8 or a combination of grade 6,7, and 8 were included in the middle school math teacher group (n = 93). Teachers who indicated they currently teach science in grades 6, 7, or 8 or a combination of grade 6,7, and 8 were included in the middle school science teacher group (n = 43). The two groups combined produced a group size of 136 which exceeds the minimum required sample size of 100 for an independent samples t test for a medium effect size at a statistical power of 0.7 at the 0.05 level (Gall et al., 2007).

Results

Assumption Tests

The dependent variables of Personal Teaching Efficacy and Beliefs (PTEB), Teaching Outcomes Expectancy Beliefs (TOEB), and STEM Instruction were screened for inconsistencies and outliers (Gall et al., 2007). There were no outliers identified in the data related to PTEB and STEM instruction. For the dependent variable TOEB, there were no extreme outliers (Gall et al, 2007, Laerd Statistics, 2015, Warner, 2013). See Figure 1 for box and whisker plots.

Figure 1



Normality was examined using a Kolmogorov-Smirnov test. This test of normality was used because it is appropriate for sample sizes greater than 50 (Warner, 2013). The results of the

Kolmogorov-Smirnov test revealed the assumption for normality was not met ($p < .05$). See Figure 2 for Kolmogorov-Smirnov results. Histograms for each data set were also included as another indicator that the assumption of normality was not met. See Figure 3 for histograms.

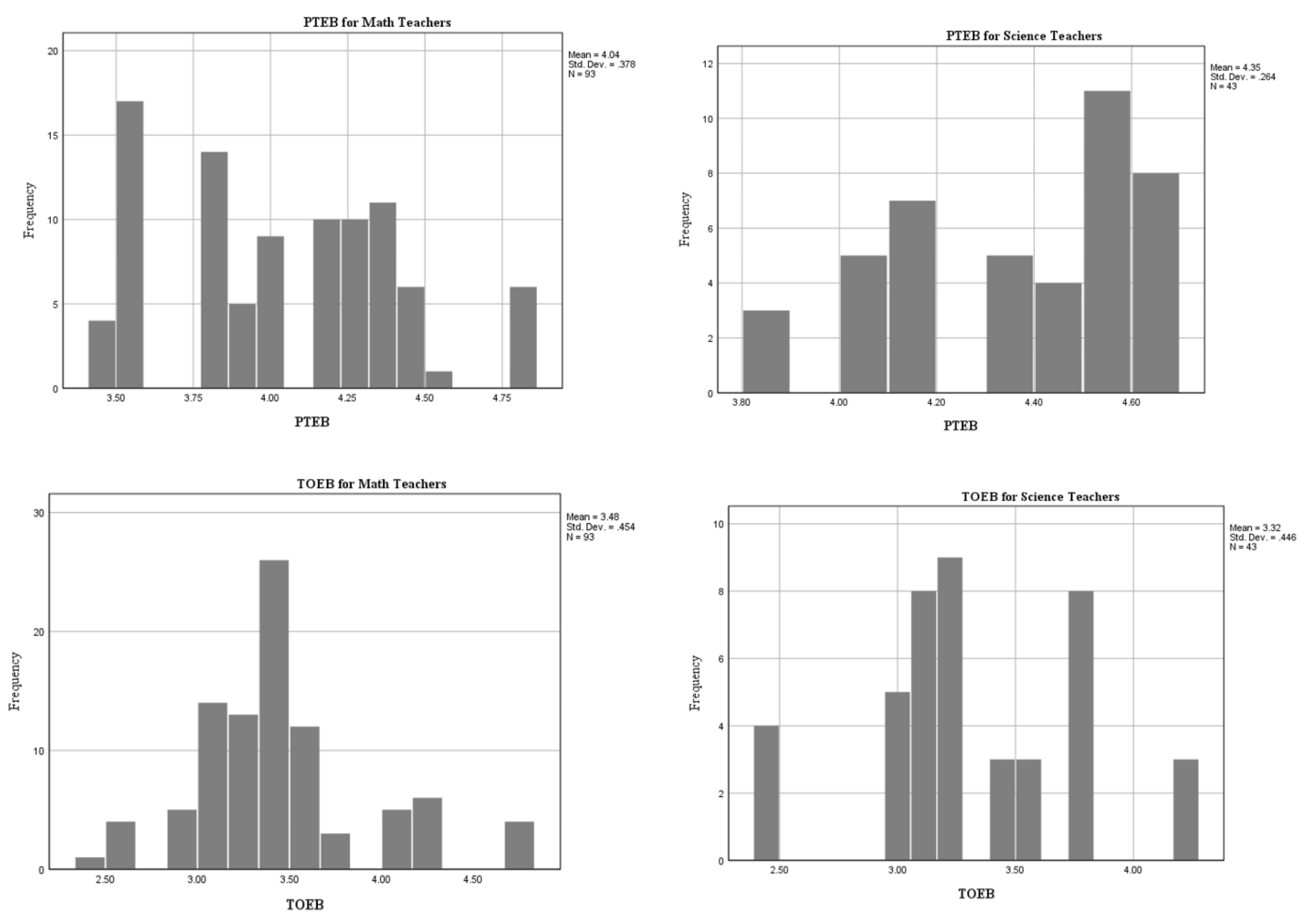
Figure 2

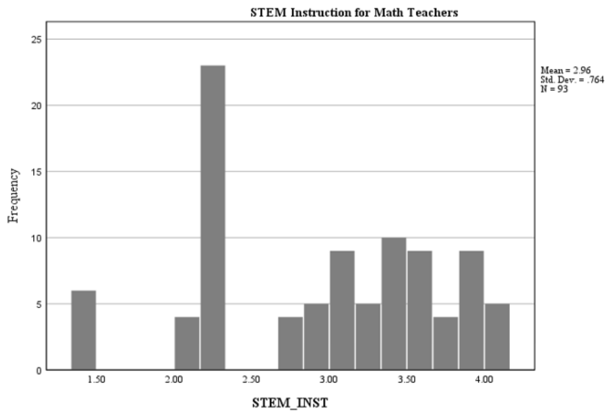
Tests of Normality

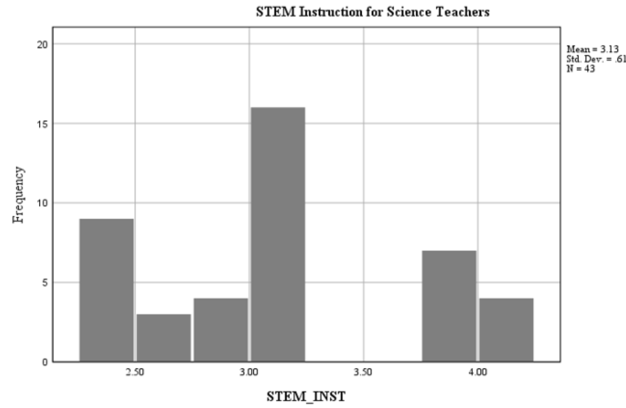
		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Subject_Taught	Statistic	df	Sig.	Statistic	df	Sig.
PTEB	Mathematics	.131	93	.000	.938	93	.000
	Science	.211	43	.000	.867	43	.000
STEM_INST	Mathematics	.167	93	.000	.929	93	.000
	Science	.187	43	.001	.902	43	.001
TOEB	Mathematics	.205	93	.000	.923	93	.000
	Science	.187	43	.001	.929	43	.011

a. Lilliefors Significance Correction

Figure 3







Homogeneity of variance was tested using the Levene's Test. There was no violation of the homogeneity of variance for Teacher Outcomes Expectancy Beliefs (*p* = .671). However, the assumption of homogeneity of variances was violated for Personal Teaching Efficacy and Beliefs (*p* = .005) and STEM Instruction (*p* = .015). Since the assumption of normality was not met, and the homogeneity of variance was also violated, the researcher decided to use a Mann-Whitney U test. The Mann-Whitney U Test is a nonparametric alternative to the independent-samples t-test (Gall et al, 2007, Laerd Statistics, 2015, Warner, 2013). See Figure 4.

Figure 4

Test of Homogeneity of Variance

		Levene Statistic	df1	df2	Sig.
PTEB	Based on Mean	8.178	1	134	.005
	Based on Median	7.857	1	134	.006
	Based on Median and with adjusted df	7.857	1	132.212	.006
	Based on trimmed mean	8.473	1	134	.004
TOEB	Based on Mean	.182	1	134	.671
	Based on Median	.066	1	134	.798
	Based on Median and with adjusted df	.066	1	133.696	.798
	Based on trimmed mean	.259	1	134	.612
STEM_INST	Based on Mean	6.064	1	134	.015
	Based on Median	4.334	1	134	.039
	Based on Median and with adjusted df	4.334	1	130.377	.039
	Based on trimmed mean	5.798	1	134	.017

For the Mann-Whitney U test, the study design has four assumptions that needed to be met. The first assumption is the dependent variable(s) are measured at the continuous or ordinal level. For this study, the dependent variables are measured at the ordinal level. Participants answered a series of questions pertaining to each of the dependents variables (Personal Teaching Efficacy and Beliefs, Teacher Outcomes Expectancy Beliefs, and STEM Instruction) using a Likert scale and the average of these responses resulted in one value for that variable. The second assumption is there is one independent variable consisting of two independent groups. The independent variable for this study (middle school teacher) has two categories, math and science. The third assumption is there is independence of observations, meaning there is no relationship between the observations of each group. The participants in this study had independence of observations as each participant has his or her own score and belongs to only one group (math or science).

The fourth assumption is the distribution of scores for each group have a similar shape (Gall et al, 2007, Laerd Statistics, 2015, Warner, 2013). To determine whether or not the data met this assumption, the Levene Statistic based on median was used. Only the variable of Teacher Outcome Expectancy Beliefs (TOEB) met this assumption (p = .798). The other two variables, Personal Teaching Efficacy and Beliefs (p = .006) and STEM Instruction (p = .039) did not.

Null Hypothesis 1

The first null hypothesis states, "There is no statistically significant difference between personal teaching efficacy and beliefs of middle school math teachers and middle school science teachers." This hypothesis addressed the independent variable (middle school teachers) on the dependent variable (personal teaching efficacy and beliefs).

A Mann-Whitney U test was completed to determine if there were differences in the personal teaching efficacy and beliefs (PTEB) between middle school math teachers and middle school science teachers. Distributions of the PTEB scores for middle school math teachers and middle school science teachers were assessed both visually and statistically and determined to not be similar. PTEB scores for middle school mathematics teachers (mean = 57.56) were significantly lower than middle school science teachers (mean = 92.15), $U = 982.5$, $z = -4.782$, $p = .000$, $\eta^2 = 0.17$ (Gall et al, 2007, Laerd Statistics, 2015, Warner, 2013). The distributions not being similar, the researcher was unable to reject the first hypothesis. It can be concluded that the personal teaching efficacy and beliefs of middle school math teachers did have a lower mean than the personal teaching efficacy and beliefs of middle school science teachers.

Null Hypothesis 2

The second null hypothesis states, "There is no statistically significant difference between the teaching outcome expectancy beliefs of middle school math teachers and middle school science teachers." This hypothesis addresses the independent variable (middle school teachers) on the dependent variable (teaching outcomes expectancy beliefs).

A Mann-Whitney U test was completed to determine if there were differences in the teaching outcomes expectancy beliefs (TOEB) between middle school math teachers and middle school science teachers. Distributions of the TOEB scores for middle school math teachers and middle school science teachers were visually and statistically assessed and determined to be similar. Median TOEB scores for middle school mathematics teachers (3.44) and middle school science teachers (3.22) were not statistically significantly different, $U = 1638$, $z = -1.707$, $p = 0.088$, $\eta^2 = .02$ (Gall et al, 2007, Laerd Statistics, 2015, Warner, 2013). Therefore, the researcher failed to reject the second hypothesis; the teaching outcomes expectancy beliefs of middle school math teachers did not differ significantly from the teaching outcomes expectancy beliefs of middle school science teachers.

Null Hypothesis 3

The third null hypothesis states, "There is no statistically significant difference between the use of STEM instructional practices of middle school math teachers and middle school science teachers." This hypothesis addresses the independent variable (middle school teachers) on the dependent variable (STEM Instructional Practices).

A Mann-Whitney U test was completed to determine if there were differences in the STEM instructional practices between middle school math teachers and middle school science teachers. Distributions of the STEM instructional practice scores for middle school math teachers and middle school science teachers were visually and statistically assessed and determined to not be similar. STEM instructional practice scores for middle school mathematics teachers (mean = 65.85) and middle school science teachers (mean = 74.22) were not statistically significantly different, $U = 1753.5$, $z = -1.154$, $p = 0.248$, $\eta^2 = .01$ (Gall et al, 2007, Laerd Statistics, 2015, Warner, 2013). For this reason, the researcher failed to reject the second hypothesis; the STEM instructional practices of middle school math teachers did not differ significantly from the STEM instructional practices of middle school science teachers.

CHAPTER FIVE: CONCLUSIONS

Overview

This chapter discusses the results of the study on the comparison of the beliefs and efficacy towards STEM education of middle school math teachers and middle school science teachers. The discussion addresses each of the research questions for this study and how these results relate to current research and literature. This chapter also addresses how the knowledge gleaned from the study can be used to improve STEM education and focus efforts of educators who are training others in STEM instructional practices. Finally, limitations of the study will be addressed along with recommendations for future research.

Summary of Findings

There were three hypotheses being addressed in this study. The first null hypothesis was "There is no statistically significant difference between personal teaching efficacy and beliefs of middle school math teachers and middle school science teachers." The distributions for the data related to this hypothesis were not similar and the null hypothesis could not be rejected. However, there was a distinctive difference in the mean scores between middle school math and science teachers; with middle school math teachers having a lower score.

The second null hypothesis was "There is no statistically significant difference between the teaching outcome expectancy beliefs of middle school math teachers and middle school science teachers." Again, the distributions of the data were not similar, and the null hypothesis could not be rejected. There was also no significant difference between the mean scores of middle school math teachers and middle school science teachers.

The third null hypothesis was "There is no statistically significant difference between the frequency of use of STEM instructional practices of middle school math teachers and middle school science teachers." Again, the distributions of the data were not similar, and the researcher failed to reject the null hypothesis. There was also no significant difference in the mean scores between middle school math teachers and middle school science teachers.

Discussion

The purpose of this causal comparative quantitative research study was to determine if there is a difference between the perceptions of middle school math teachers and middle school science teachers concerning their teaching efficacy and beliefs, teaching outcome expectancy, and use of STEM instructional practices as it pertains to Science, Technology, Engineering, and Math (STEM) education. Data was compiled from the *Teacher Efficacy and Attitudes toward STEM (T-STEM)* survey to determine how teachers' responses differ based on the subject area they teach. The survey was sent out via email to middle school math and middle school science teachers in southeastern Georgia. Teachers completed a Likert scale survey addressing the areas of Personal Teaching Efficacy and Beliefs, Teaching Outcome Expectancy Beliefs, Student Technology Use, STEM Instruction, 21st Century Learning Attitudes, Teacher Leadership Attitudes, and STEM Career Awareness. Only the areas of Personal Teaching Efficacy and Beliefs, Teaching Outcome Expectancy Beliefs, and STEM Instruction were analyzed for this study.

Personal Teaching Efficacy and Beliefs

The study first sought to determine if there is a difference between the personal teaching efficacy and beliefs of middle school math teachers and middle school science teachers. Teacher Efficacy is defined as a teacher's belief in his or her own teaching ability and the teacher's beliefs in the power of the teacher to reach difficult students (Protheroe, 2008). This definition is derived from the self-efficacy concept of Bandura (1977) that one's behaviors and beliefs determine their confidence and persistency towards being successful. This portion of the survey focused on teachers responding to statements about their confidence in being able to teach the necessary skills needed to learn math or science as well as their confidence in being able to reach all students and increase interest in their subject area.

Results of the study concluded the distribution of scores for PTEB were not similar and therefore only the mean scores for middle school math teachers and middle school science teachers could be compared. For math teachers, the mean of 57.56 was significantly lower than the mean of 92.15 of science teachers. This difference in mean scores reflects the idea that middle school science teachers have a stronger confidence in their ability to teach science and their ability to reach all students (Friday Institute for Educational Innovation, 2012). Boaler (2016) found math instructors, when compared to other STEM subjects, tended to have a more fixed mindset in the classroom. According to Boaler (2016), a fixed mindset in mathematics translates into the belief a person's math ability is innate and cannot be changed. This fixed mindset can also be responsible for limiting the strategies a teacher uses in the classroom and for influencing the teacher's belief that only select students will be successful in the classroom (Boaler, 2016; Sun, 2018).

Often times, mathematics teachers perpetuate this fixed mindset and in turn perpetuate a lower teacher efficacy based on how the students are scheduled into their classes. In the middle school, students are offered opportunities to participate in accelerated math courses based on their ability. At the same time, students who have shown they need extra help in math may be scheduled into remedial classes. While this sounds like a good practice in theory, it can lead to ability grouping in math classrooms. By ability grouping, teachers are sending the message a student's ability to learn math is fixed based on his or her placement and in turn, reinforcing this concept in the teacher's mind (Sun, 2018).

Teacher efficacy and confidence in the classroom is also directly related to the teacher's feeling he or she has a deep understanding of the content. It has been found mathematics teachers in the United States are not comfortable with the current mathematics curriculum due to not being adequately prepared to teach it, not having deep content knowledge, and not having a mastery of effective teaching strategies for mathematics (Schmidt, Houang, & Leland, 2011; Posamentier & Krulik, 2016). This feeling of unpreparedness in preservice teachers can lead to high levels of math anxiety. Studies have found that teachers who have math anxiety also tend to have a negative attitude towards teaching mathematics. This in turn leads to negative student achievement due to less effort being placed on the area of mathematics (Gresham, 2018; Hollingsworth & Knight-Mckenna, 2018). These results could be reflective of a lack of preparation of mathematics teachers as compared to science teachers.

It has been noted by the National Council of Teachers of Mathematics effective mathematics teaching practices and beliefs need to reflect an inquiry-based approach (Stipek, Givvin, Salmon, & MacGyvers, 2001). While this is a best practice for all math teachers, it is especially aligned with the ideas of many STEM programs promoting a blended math and science classroom experience relying heavily on the engineering process and problem-based learning. This type of teaching also requires the teacher to have a high-level of self-confidence in their ability to teach math concepts (Stipek, Givvin, Salmon, & MacGyvers, 2001). In a recent study on growth mindset in mathematics teaching, Sun (2019) found even when teachers think they are teaching in a inquiry-based, growth mindset context, they often times still incorporate traditional math teaching practices negating this belief.

Consequently, the lower mean-rank score for middle school mathematics teachers in this study is another indicator of the power traditional teaching practices still hold in the mathematics classroom. Boyd & Ash (2018) found professional learning can be effective in reforming teacher beliefs about grouping and mindset. The results of this study further perpetuate there is a need for work in the area of changing the self-efficacy and beliefs of middle school math teachers.

In the area of middle school science curriculum and instruction, there has a been a strong movement recently to revise the national science standards (Pratt, 2011). These revised standards increased the rigor expectations for students and included professional learning for science teachers to become more familiar with the standards and how they are taught (Lee, Muiller, & Januszyk, 2014). This is in contrast to the many changes mathematics curricula has undergone without strong professional learning to support it. Jackson and Ash (2011) found professional learning incorporating the 5-E Lesson Plan (Engage, Explore, Explain, Elaborate, and Evaluate) along with developing academic vocabulary increased science teachers' content knowledge and confidence in teaching science. These types of professional learning opportunities also lead to an increase in the teachers' belief they can impact student achievement. This may be another factor in the higher confidence level of science teachers in their belief their actions have a strong impact on student learning.

Teaching Outcomes Expectancy Beliefs

The second research question this study sought to determine is if there is a difference between the teaching outcome expectancy beliefs of middle school math teachers and middle school science teachers. Teacher outcome expectancy is the degree to which the teacher believes student learning in the specific STEM subject can be impacted by the teacher (Friday Institute for Educational Innovation, 2013). The teaching outcomes expectancy and beliefs portion of the T-STEM survey had the teacher respond to statements that reflected how they felt about the teacher's role in students' increase interest and performance in the subject area.

The results of the study in the area of teaching outcome expectancy and beliefs concluded there was not a significant difference between middle school math teachers and middle school science teachers. The median scores for teacher responses in each subject area were very similar, both rating teaching outcome expectancy beliefs in the "neither agree nor disagree" range. This lack of a strong belief in the positive impact of teaching on the outcome of students may stem from changes in the curriculum for both mathematics and science as well as the testing requirement for both subjects and pacing guides that are implemented by school districts (Kelly & Knowles, 2016; Boaler, 2019; Sun, 2019).

While there has been more training accompanying new science standards, a recent study conducted with pre-service teachers found an increase in anxiety amongst teachers could lead to a lack of confidence and belief in their ability to effectively teach the subject (Buss, 2010; Senlar, 2016). The curricular changes implemented in math and science, which require more active learning experience and an emphasis on conceptual understanding, have been shown to lead to an increase in teacher anxiety (Thomson, DiFrancesca, Carrier, & Lee, 2017). This increase in anxiety can cause teachers to limit their instructional strategies to one-dimensional practices, which are defined as teacher centered practices not incorporating problem solving and critical thinking skills (Boaler, 2016; Sun, 2019).

It is interesting to note while middle school science teachers had a higher mean related to Personal Teaching Efficacy and Beliefs, this did not translate to higher Teacher Outcome Expectancy Beliefs. In modern day classrooms, there are three processes that teachers must address to have a quality classroom. These areas are instructional support, classroom organization, and emotional support (Zee & Koomen, 2016). Teachers with high teaching efficacy can be hindered by negative student behaviors. Additionally, the emotional support of students has a large impact on outcomes. There are few studies available addressing the impact that social emotional education has on teachers' and students' outcome expectancy (Zee & Koomen, 2016). Even though, this is another area that teachers are asked to incorporate into their classroom practices. This further depletes the amount of time they can devote to implementing effective instructional strategies that impact outcome expectancy.

As stated with teacher efficacy, a teacher's outcome beliefs are affected by school policies and practices. For instance, if the school has a process in place of ability grouping students, it can cause the teacher to have a lesser outcome expectancy for the students if they are not in a high-ability grouping (Sun, 2019). Another factor affecting the Teacher Expectancy Outcomes and Beliefs is the support they receive from the school to implement projects or problem-based learning experiences. If the school's class time is too short or if there is not a budget to support the purchase of supplies to support engaging activities, teachers may be forced to use instructional strategies that are not ideal for this type of teaching and learning (Sun, 2019). Finally, the pacing guides used by a school district may contribute to teachers feeling they do not have time to properly engage the students in learning tasks that lead to higher outcome expectancies. They are pushed to cover the content standards before state testing begins.

One other major barrier to reducing teacher anxiety due to curricular changes, is the use of standardized test scores as an accountability measure for teachers. When the pressure to perform well on these types of assessments is coupled with increased anxiety, teachers will tend to revert to traditional, teacher-centered pedagogy and focus on basic skills (Swars, Daane, &

Gieson, 2006). Often times, standardized tests focus solely on mathematics and language arts, This leads to some schools increasing instructional time for these subject areas and taking away from science and social studies. For these reasons, teachers may feel that they have less autonomy to effect student learning and revert to a "one-size fits all" model when put under pressure. Additionally, science teachers may feel their subject area is less valued and not be given as much time in class as the other subjects to implement effective instructional strategies.

While middle school teachers often know the best strategies for teaching math and science in a way that leads to higher outcome expectancy, they can be hampered by the expectations of the school, school district and state. The results of the Teacher Outcome Expectancy and Beliefs portion of this study contributes to the understanding teachers do not always believe their actions can positively impact students' achievement. However, it has been found that these beliefs can be changed through professional learning and teacher reflections on classroom experiences and teaching practices (Stipek, Givvin, Salmon, & MacGyvers, 2001; Boyd & Ash, 2018).

STEM Instructional Practices

The third and final research question this study sought to garner feedback on was the difference between the use of STEM Instructional Strategies of middle school math teachers and middle school science teachers. According to the Friday Institute for Educational Innovation (2013), STEM instructional practices relate to investigative problem solving, making predictions, observations, data collections, and "real-world" context. While the mean score for math teachers was slightly lower than science teachers in this area, the results of the study concluded that there was no significant difference between the use of STEM instructional strategies of middle school math teachers and middle school science teachers.

The mean score for math and science teachers for the use of STEM instructional strategies was near the middle indicating it was not a strong use of or lack of use of STEM instructional practices. This result is aligned with the findings teachers in middle school are still teaching in primarily isolated environments and using a curriculum more procedural in nature rather than being focused on applying a deep understanding of the concepts (Masters, 2016; Harnett, 2016). While research shows the teaching of mathematics and science should include problem-solving and critical thinking practices integrating the subjects, these practices are still not the norm for the classroom (Honey et al., 2014; Vasquez, Comer, & Villegas, 2017). This is, in part, due to the fact teachers who embrace the STEM instructional practices need to be well versed in the content, comfortable facilitating student learning, and flexible in their teaching practices. There have been several studies finding teachers of mathematics and science, especially in early childhood education, are not strong in their conceptual understanding of the concepts being taught (Buss 2010). In other words, they are not adequately prepared to teach these subjects in the manner that STEM instructional strategies suggest.

Another aspect to consider is STEM instructional practices often involve the incorporation of the academic disciplines of Science, Technology, Engineering, and Math. This study had the two groups, middle school math teachers and middle school science teachers take a survey tailored to their content area. The middle school teachers surveyed only taught math or science and were not part of a blended model. By keeping these subjects separated, it requires more intentional planning of the types of cross-curricular, real-world performance tasks that are key components of the STEM instructional model (Faber et al, 2013).

Implications

This study provides insight into the personal teaching efficacy and beliefs, teaching outcome beliefs, and the use of STEM instructional practices of middle school math and middle school science teachers as they are encouraged to implement an integrated STEM program into their classrooms. The difference in the mean for personal teaching efficacy and beliefs between the two subjects, specifically math teachers having a lower mean than science teachers, provides insight into the need for professional learning for mathematics teachers. The areas of need being the use of teaching strategies addressing the implementation of critical thinking and creative problem solving. It also indicates the need for middle school mathematics teachers to have a stronger conceptual understanding of the mathematics they are teaching so they can better build this understanding in their students. It has been noted in research studies teachers must be immersed in their academic subjects and able to develop advanced thinking and problem-solving skills in their students to support high standards of learning and increase teacher efficacy (Green & Kent, 2016; Lotter et al., 2016). This is achieved through professional learning opportunities.

While the areas of teaching outcome expectancy beliefs and the use of STEM instructional strategies by middle school math and science teachers was not significant for teachers in this survey, the lack of a strong positive response to these areas on the survey indicates there is still a need to provide professional learning increasing teachers' belief that they are able to impact every students. This can be achieved by providing a strong conceptual framework for an integrated approach to STEM education and building teacher confidence in that approach (Kelly & Knowles, 2016). Teachers also need to be reassured they have the autonomy to implement instructional practices allowing the facilitation of learning and integrating the areas of science, technology, engineering, and math into their classroom. Too many teachers are still allowing the traditional practice of operating math and science classes in isolation of one another and the use of standardized tests to stifle the learning opportunities in the classroom (Honey, Pearson, & Schweingruber, 2014). It is also important to note the use of STEM instructional strategies had the lowest mean score for mathematics teachers. It seems to be more difficult for math teachers to teach in a classroom that integrates problem-based learning, a key component to effectively implementing STEM education into the classroom.

Limitations

There were several factors presenting as limitations for this study. One factor is the survey was given in a specific geographic area. The teachers in this area all teach using the Georgia Standards of Excellence and are exposed to many of the same professional learning opportunities. For this reason, they may have a similar mindset when answering questions about teacher efficacy and beliefs and the integration of STEM instructional practices.

Another limiting factor is the difference in the number of teachers who responded to the survey from each subject area. There were more than twice as many math teachers who responded to the survey than science teachers. Statistically, the more responses received the more likely the data reflects the groups being surveyed. While statistical tests compensate for these differences, there is still the possibility there may be concerns with the internal validity of the study.

Finally, the demographics of the study must be considered when looking at limiting factors. In this study, 84% of the respondents were white and only 16% were black. This is not reflective of the teacher workforce in Georgia which is 60% White, 21% Black, and 10% Hispanic (Tio, 2018). This study had a much higher percentage of white respondents and no respondent who represented the Hispanic population. This is another indicator the results are not reflective of the entire teacher workforce in Georgia.

Recommendations for Future Research

There are several recommendations for future research in this area. First, this study was conducted in a limited area involving school districts in southeast Georgia. A larger study that expands beyond just this localized area would give better insight into the beliefs of middle school math and science teachers and their use of STEM instructional strategies in the classroom. Additionally, much of the current research relates to pre-service teachers and therefore it would be beneficial to expand the survey to include teachers who are veteran teachers at all grade levels, not just middle school. STEM education is a K-12 initiative and it would be beneficial to examine it at this level.

STEM education in Georgia is a growing area. The Georgia Partnership for Excellence in Education (GPEE) collected data from various institutions and created a map to indicate where investments have been made in STEM education (Georgia Partnership for Excellence in Education, 2019). This map indicates that the majority of investments center around the Atlanta area and have are not yet widespread throughout the state. Therefore, further research that is inclusive of the areas where more investments have been made may change the outcomes of the survey. A comparison could then be made between the attitudes of teachers in areas with a higher investment as compared to those having very little investment in STEM education.

It was also noted that the demographics of the teachers who responded to this survey were predominately white and did not reflect the demographical make up of teachers in the state of Georgia. Expanding the study to be more inclusive of all teachers in the state, specifically those who are black and Hispanic, would provide a better comparison of the beliefs towards

STEM education for middle school math and middle school science teachers in Georgia. The study could then be expanded to note any similarities and differences in scores as they relate to race. Similarly, with a more diverse group that included more male participants, comparisons could be made that reflect discrepancies between beliefs based in gender.

In this study, middle school math teachers had a lower mean score than middle school science teachers in the area of Personal Teaching Efficacy and Beliefs. Additionally, it was found that teachers of mathematics may not be as well prepared in teaching in their content area as teachers of science. Statistics on teacher demographics in Georgia show that the number of teachers certified in secondary science is 2% higher than any other secondary subject area (Tio, 2017). Further research is recommended in this area to determine how teachers are being prepared to teach these subjects. There are traditional and non-traditional routes to certification that provide very different experiences for pre-service teachers. This information could give insight into why science teachers feel better prepared to teach science and how to improve these preparation programs.

Another recommendation would be to use the survey as a pre/post assessment when implementing professional learning addressing teacher efficacy and STEM instructional strategies. This would provide an environment before professional learning where teachers are focused on a true self-analysis of their teaching practices. Giving the survey again as a post assessment would provide specific feedback about the effectiveness of the professional learning and its impact on the teaching practices and efficacy of the teachers involved.

Finally, further research is needed on how to assess an effective STEM program and its impact on students. Schools still give subject specific, standardized tests and implement strictly content-based curricula. This perpetuates the isolation of these subject areas (Kelly & Knowles, 2016). Even in this study, the researcher only looked at mathematics and science, however technology and engineering are key components of an effective STEM program yet these areas are not as prevalent in school programs (English, 2016, Wang& Nam, 2015). It would be beneficial for educators and policy makers to see what constitutes an effective Science, Technology, Engineering, and Math program that has a positive impact on student learning.

Summary

This study provided insight into the implementation of STEM education into middle school math and science classrooms. The data collected did not reflect any statistically significant differences between the personal teaching efficacy and beliefs, teacher outcome expectancy beliefs, and use of STEM instructional practices between middle school math and science teachers. It did indicate limitations and areas for future research. The small region the study was conducted in did not provide enough diversity among the participants and did not accurately reflect the demographics of teachers in Georgia.

It will be beneficial for future researchers to expand the area the study is conducted in. By encompassing a large region, information can be obtained from a more diverse group. Researchers will be able to compare the differences in responses and the implementation of STEM based on ethnicity, sex, and geographical region. The information from these comparisons would allow for the development of professional learning specific to the different groups.

Finally, the impact that an integrated approach to STEM education has on student outcomes is essential. There is research to support the need for these programs and the need for students to be better prepared to enter a global workforce. The evaluation of these programs and their effectiveness need to be assessed beyond just student outcomes on standardized tests.

Ultimately, the goal for STEM education is to create students who can think critically and provide solutions to future problems.

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Appendix A: Comparison Chart

T-STEM for Mathematic	T-STEM for Science
S1Q1: I am continually improving my ***mathematics*** teaching practices.	S1Q1: I am continually improving my ***science*** teaching practices.
S1Q10: When teaching ***mathematics***, I am confident enough to welcome student questions.	S1Q10: When teaching ***science***, I am confident enough to welcome student questions.
S2Q9: Minimal student learning in ***mathematics*** can generally be attributed to their teachers.	S2Q9: Minimal student learning in ***science*** can generally be attributed to their teachers.