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Non-Science, Technology, Engineering, Mathematics Teachers' Efficacy For Integrating Mathematics Across the Curriculum

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This is to certify that the doctoral study by

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Abstract

Non-Science, Technology, Engineering, Mathematics Teachers' Efficacy

For Integrating Mathematics Across the Curriculum

by

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MST, George Washington University, 1972

BS, Hampton University, 1969

Doctoral Study Submitted in Partial Fulfillment

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Abstract

The problem at a local science, technology, engineering, mathematics (STEM) charter high school in this study, was that non-STEM teachers lacked the self-efficacy and background knowledge to integrate mathematics into their content-specific instructional activities. The goal of this study was to explore non-STEM teachers' self-efficacy for integrating mathematics across the STEM charter high school's curriculum. The conceptual framework of self-efficacy informed the study. A case study research design was chosen to develop an in-depth understanding of the problem. . Twelve of the 16 local school's non-STEM teachers agreed to participate in the study. Personal interviews were conducted to access non-STEM teachers' perspectives about mathematics integration, the challenges they encounter with meeting this requirement, and the strategies and resources needed to assist them with integrating mathematics into their disciplines. Data analysis consisted of coding and thematic analysis which revealed patterns related to the need for increasing teachers' self-efficacy for integrating mathematics into their instruction. Findings indicated a need for a professional development training project that provided course-specific examples of integrating mathematics into other content areas and increased collaboration between non-STEM and STEM teachers to plan and implement interdisciplinary lessons that include mathematics applications. Positive social change might occur as teachers who feel comfortable with STEM content across the curricula will be better able to meet the needs of all students and students who graduate with STEM capability will be well prepared for college and career paths.

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Dedication

This work is dedicated in memory of my parents, Rev. Alexander D. Williams and Cleopatra W. Williams, who instilled in me an undying faith in God, a passion for education, and a tenacity to succeed. They always gave me the support and encouragement I needed to overcome challenges in my life.

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Section 1: The Problem

Introduction

Science, Technology, Engineering, and Mathematics (STEM) education involves the planning and implementation of programs that provide students with opportunities to experience and practice real-life applications of the knowledge and skills related to the core STEM disciplines: science, technology, engineering and mathematics (Bybee, 2013). Common characteristics of the academic programs offered by STEM high schools include comprehensive course requirements and electives directly related to the core STEM disciplines (Bruce-Davis et al. 2014; Kennedy & Odell, 2014). Students attending STEM-focused schools engage in authentic problem solving, internships and comprehensive, academic projects that showcase their abilities to apply their knowledge and skills (Bruce-Davis et al., 2014; Kennedy & Odell, 2014).

Schools with a STEM-focused curriculum have emerged across the United States in response to the urgent need for qualified workers in STEM-related fields (Kennedy & Odell, 2014). The urgency to increase the STEM workforce is fueled by the national interest of keeping the United States globally competitive in the 21st century economy (Johnson, 2013; Mohr-Schroeder, Cavalcanti & Blyman, 2015; Rinke, Gladstone-Brown, Kinlaw & Cappiello, 2016; Roberts, 2013). Policy makers and education leaders agree that the United States must improve STEM teaching and learning across all grade levels K-12 (Moore, Johnson, Peters-Burton, & Guzey, 2016). Improvement in STEM education on these levels is directly related to improving the U. S. global economy and increasing the number of qualified people prepared to enter a job market dominated by STEM-related professions (Moore et al., 2016).

Many advocates of STEM education believe STEM subject areas should be taught via an integrated approach involving interdisciplinary instruction between at least two STEM content areas. The approach can also involve interdisciplinary planning and instruction that integrates the content of a STEM subject area with one or more other school subject areas, such as English language arts, social studies, fine arts and world languages (Corlu, Capraro, & Capraro, 2014; Johnson, 2013; Sanders, 2009). Meeting the goals described by these characteristics requires quality instruction that has been planned and implemented by teachers working collaboratively to create interactive and engaging lesson activities (Kelley & Knowles, 2016; Mohr-Schroeder et al., 2015; Rinke et al., 2016). Interdisciplinary planning between teachers of non-STEM and STEM courses is needed to enable students to connect and apply content skills across the curriculum (Ciecieerski & Bintz, 2015; Hintz & Smith, 2013; Roberts, 2013; Wheland, Donovan, Dukes, Qammar, Smith, & Williams, 2013).

According to Moore and Smith (2014), an integrated STEM curriculum fosters improved mathematics and science achievement as well as an interest in engineering design. This curriculum also increases technology literacy and connects STEM content subject areas to other subject areas. For example, integrating mathematics with reading instruction can maximize students' comprehension of literary and informational texts

(Hintz, 2013). Students can connect their learning and life experiences by learning mathematics in meaningful contexts (Ciecierski & Bintz, 2015).

The Local Problem

At an urban STEM charter high school, teachers of non-STEM courses are required to integrate mathematics into their instructional activities. These requirements are reflected in the school's charter renewal document which emphasizes the importance of students acquiring and practicing literacy and numeracy skills in all disciplines. All teachers who are a part of the faculty of the STEM school chosen for this study are required to incorporate literacy and numeracy skills across the curriculum (STEM Charter Renewal document, 2012-2013). Numeracy refers to quantitative literacy, which involves a person's ability to confidently and effectively apply mathematical skills to everyday life situations (Goos, Geiger & Dole, 2014). It is not known if and to what extent the local school's non-STEM teachers have the self-efficacy needed for integrating mathematics, which includes numeracy skills, into their content areas. The school's Teacher Evaluation Rubric for 2013-2014 included the requirement of developing and using learning activities that promote literacy and numeracy skills (STEM Teacher Evaluation Rubric for 2013-2014).

When non-STEM teachers who work at this charter high school completed a 2014 mathematics integration survey (see Appendix B: Survey: Mathematics Integration), they said that they needed support to integrate mathematics and technology applications into their disciplines effectively. However, this survey had a poor response rate (only 5 out of 13 teachers responded). Furthermore, it was not designed to capture the in-depth information needed to understand non-STEM teachers' feelings about their ability to make deep instructional changes.

The goal of this study was to explore non-STEM teachers' self-efficacy for integrating mathematics across the STEM charter high school's curriculum. Self-efficacy influences the decisions people make as they engage in challenging tasks and the levels of competence and confidence they will have about engaging in those tasks (Bandura, 1994; Pajares, 1996). Teachers with high levels of self-efficacy feel more competent and confident about planning and implementing enriching learning activities (Bandura, 1993; Holzberger, Philipp & Kunter, 2013; Hoy & Spero, 2005; Pajares, 1995; Peebles & Mendaglio, 2014). According to Bandura (1994) people with high levels of self-efficacy have more motivation and exert greater effort and persistence towards successfully completing activities. Understanding non-STEM teachers' self-efficacy for integrating mathematics into their instruction will determine the role their confidence and competence plays in meeting the requirement of integrating mathematics across the curriculum. According to Seals, Mehta, Berzina-Pitcher and Graves-Wolf (2017), teacher efficacy is the belief and confidence a teacher has to effect desired learner outcomes. Without knowing this information, it would be difficult to find solutions to the local problem.

Integrating mathematics across the curriculum is often challenging to non-STEM teachers. In their case study of eight STEM high schools, Peters-Burton, Lynch, House, and Han (2015) found that mathematics was the most difficult subject and the one least often integrated across the curriculum. Peters (2013) argued that teachers may lack the self-efficacy and background learning experiences needed to develop engaging student learning activities that integrate mathematics into their disciplines effectively. They called for further research regarding teacher previous knowledge and background experiences. According to Mintzes, Marcum, Messerschmidt-Yates and Mark (2013), the quality of STEM instruction improves and student achievement increases when teachers can collaborate in well-organized professional learning communities (PLCs). School administrative teams must provide the critical support and time for collaboration among teachers who have varied licensures and backgrounds. Integrated STEM education is one way to connect competencies across the curriculum to make them more relevant to students (Moore & Smith, 2014).

Researchers often refer to STEM in the context of K-12 interdisciplinary instruction (Israel, Maynard, & Williamson, 2013). Quality STEM education should involve collaboration among all educators (K-12 and post-secondary), community leaders, and business organizations to plan and implement effective STEM instruction that prepares students to become competitive in a global, technology oriented society (Mohr-Schroeder et al., 2015). The importance of STEM education to the sustainability of worldwide competitiveness was supported by the Obama administration's *Change the Equation* initiative that was created to motivate more Americans to prepare for employment in STEM career fields (Mohr-Schroeder et al., 2015).

According to Bybee (2013), STEM literacy, that is, the understanding and application of STEM concepts to solve STEM-related real-world problems needs to become the first step to advancing STEM education. Becoming STEM literate is vital to the use of integrative approaches for teaching STEM content across the curriculum (Bybee, 2013). The STEM generation must be able to address society's needs for new technological and scientific advances, related to everyday life situations (Bybee, 2013).

Rationale

Responses to the 2014 mathematics integration survey (see Appendix B) provided suggestions regarding some of the kinds of support non-STEM teachers might need to integrate mathematics across the curriculum effectively. These teachers asked for help with integrating mathematics with literature and current events, or more ways of connecting mathematics to reading in their content areas. They also asked for creative games related to their lesson activities that would incorporate mathematics concepts. The extant literature indicates (a) that teacher perceptions influence the design of STEM integration in classroom practices and (b) the need for on-going professional development to assist teachers with effectively integrating STEM content into their instructional practices (Nadelson, Callahan, Pyke, Hay, Dance, & Pfiester, 2013; Wang et al., 2013).

The interdisciplinary approach to helping students develop STEM projects helps both teachers and students develop scientific applications that connect to real world experiences. High school students are constantly advised that they must prepare for jobs and career fields that will be needed by society in the future. Educators have placed increased emphasis on collaborative problem solving, innovative solution writing, and the use of technology across the secondary school subject areas (Berkeihiser & Ray 2013). The benefits of integrated STEM education emphasize the importance of supporting teachers with implementing integrated STEM education (Moore & Smith, 2014). However, more research is needed to set common guidelines for the development of integrative STEM curriculum and classroom practices (English, 2016; Ruggirello & Balcerzak, 2013).

The competitive world market and ensuing economic priorities has necessitated reform in mathematics education. Government leaders on the federal, state, and local levels are working vigorously to attract more of the U. S. workforce to STEM-related fields (Nunez-Pena, Pellicioni, & Bono, 2013). Understanding mathematical concepts is a critical requirement for those who plan to become a part of the STEM workforce. People who are confident in their ability to do mathematics will develop more interest in STEM fields and set goals to pursue professions in STEM career fields (Nuna-Pena et al., 2013).

The goal of this study was to explore non-STEM teachers' self-efficacy for integrating mathematics across the STEM charter high school's curriculum. Exploring the self-efficacy beliefs that non-STEM teachers in the local school have about integrating mathematics into their instruction revealed strategies and resources non-STEM teachers feel they need to meet this requirement.

Definition of Terms

Integrated STEM education: Integrated STEM Education involves interdisciplinary instruction between at least two STEM content areas. It can also involve interdisciplinary planning and instruction that integrates the content of a STEM subject area with that of one or more other school subject areas (Johnson, 2013; Kelley & Knowles, 2016; Sanders, 2009). Bryan, Moore, Johnson and Roehrig (2016) define integrated STEM education as teaching and learning of science and mathematics content integrated with engineering design content, and appropriate technologies.

Self-efficacy: Self-Efficacy is defined as a person's belief or confidence in his or her ability or competence to produce desired outcomes. Self-efficacy also involves an individual's motivational processes which include persistence of effort (Bandura, 1994).

STEM Education: STEM Education may be defined as a standards-based, multidisciplinary system that is taught using an integrative approach, that addresses the learning of the four core STEM disciplines as one dynamic (Basham & Marino, 2013). Kennedy and Odell (2014) defined STEM education as a teaching and learning process which involves integration and application of the conceptual knowledge related to the four core STEM disciplines, for the purpose of designing innovative solutions to real-world problems.

STEM Literacy: Bybee (2013) defined STEM literacy as an individual's ability to apply the knowledge and skills related to science, technology, engineering and mathematics to solve challenging environmental problems related to real-life situations.

Teacher Efficacy: Bandura (1993) associated self-efficacy with teacher efficacy, the belief and confidence a teacher has to bring about desired learner outcomes. It involves the organization and management of learner experiences to motivate and increase students' self-esteem and positive attitudes about learning (Seals et al., 2017).

Significance of the Study

Conducting research to understand the self-efficacy beliefs held by the local school's non-STEM teachers regarding integration of mathematics into their instructional activities could lead to improved planning and implementation of quality, creative, lessons that involve mathematics applications. Integrating mathematics across the curriculum enables the local school to meet its mission and goal of providing a rigorous education that prepares and motivates students to pursue a STEM-related career. The importance of STEM education to society supports the rationale for ensuring educators on all levels are equipped to teach STEM content. The findings of the study could inform future professional development, an important element for facilitating this goal (Rinke et al., 2016). Exploring teachers' self-efficacy beliefs about integrating STEM content into their instruction could inform the development of strategies and resources for motivating teachers to produce quality lessons that will ultimately help students connect classroom learning to the real world (Milner & Hoy, 2003; Hull, Booker, Naslund-Hadley, 2016; Pearson, 2017). Improved STEM instruction may result in increased motivation and better preparation for students planning to enter the STEM workforce.

Research Questions

The goal of this study was to explore non-STEM teachers' self-efficacy for integrating mathematics across the STEM charter high school's curriculum. A teacher's self-efficacy beliefs are directly related to students' achievement outcomes (Bandura, 1993; Milner & Hoy, 2003). It is not known if and to what extent these teachers have the self-efficacy needed to integrate mathematics into their content areas. The guiding research questions below are designed to gain insight about non-STEM teachers' self-efficacy (including confidence, competence, motivation, perseverance and persistence) for integrating mathematics into their instruction and to what extent their self-efficacy beliefs influence their ability to meet the local school's mandate of integrating mathematics across the curriculum.

1. What are the local school's non-STEM teachers' perceptions of their competence and confidence with respect to integrating mathematics into their instruction?
2. What factors influence the local school's non-STEM teachers' self-efficacy for integrating mathematics into their instruction?
3. How do the local school's non-STEM teachers value mathematics as a subject area that is needed in real-life? Do these value beliefs influence their motivation for integrating mathematics into their instruction?

4. How does working in a STEM educational environment affect the local school's non-STEM teachers' perseverance and persistence with integrating mathematics into their instruction?

Review of Literature

Conceptual Framework

Self-efficacy theory (Bandura, 1977) provides the structure for the conceptual framework guiding this study. According to Bandura, efficacy expectations or "a person's estimate that a given behavior will lead to certain outcomes" (p.123) determines the coping behavior and extent of effort people will exercise when confronted with adverse situations. Self-efficacy beliefs determine a person's feelings, perceptions of self-motivation and behavior regarding particular circumstances (Bandura, 1977, 1994). Bandura (1993) wrote that teachers with a strong sense of instructional efficacy persist in creating mastery experiences for students and a teacher's efficacy beliefs can predict a student's sense of mathematical and language achievement during an academic year. Successful experiences support and strengthen personal efficacy beliefs. According to Stajkovic and Luthans (2003), self-efficacy beliefs determine the amount of persistence and perseverance an individual will invest in a task, thus having a positive influence on work performance.

Bandura (1994) identified four sources of self-efficacy: mastery experiences, vicarious experiences (modeling influences), social persuasion, and emotional and physical states of being. Mastery experiences are those achieved by overcoming challenges via sustained or persistent effort. Bandura believed that mastery experiences are the most effective source for creating a strong sense of efficacy. A second source that influences the strengthening of self-efficacy beliefs is modeling influences (Bandura, 1994). Observing social models who exhibit competencies to which others aspire can inspire people to believe that they themselves are capable of managing difficult tasks and producing successful outcomes (Bandura, 1994). A third source of self-efficacy identified by Bandura is social persuasion. Verbal encouragement, positive feedback and praise may increase a person's self-efficacy (Bandura, 1994; Milner & Hoy, 2003). The fourth source that influences a person's perceived self-efficacy is his or her emotional and physical state of being. Bandura claimed that a positive attitude strengthens self-efficacy and can contribute to reduction of stress reactions when engaging in difficult tasks.

According to Seals et al. (2017), teacher efficacy is a teacher's belief and confidence in his/her ability to produce desired student outcomes in a specific context. Teachers' perceived self-efficacy is an essential part of successful teaching practices (Lee, Cawthon & Dawson, 2013). Teachers with high levels of self-efficacy demonstrate both more perseverance and persistence in helping students succeed and an increased commitment to teaching (Milner & Hoy, 2003). High levels of perceived self-efficacy lead to more active efforts to produce positive outcomes (Bandura, 1977). Teachers with high levels of self-efficacy are motivated to use more innovative strategies and approaches to instruction and are likely to design more creative student learning experiences. They have positive expectations for student learning outcomes and frequently provide more positive recognition of student successes. Students are held accountable for their learning. Teachers with high levels of efficacy feel confident in their ability to plan and implement enriching learning activities (Bandura, 1993; Pajares, 1995; Peebles & Mendaglio, 2014).

Bandura (1977) identified a difference between efficacy expectation and outcome expectancy: Efficacy expectation is the belief that one can motivate the behavior needed to produce the outcomes, while outcome expectancy is a person's belief that a given behavior will lead to certain outcomes. Individuals can believe that particular behaviors can produce certain outcomes, but have serious doubts about whether they can perform the necessary activities to produce the outcomes (Bandura, 1977). Bandura asserted that efficacy expectations determine the amount of effort and persistence a person is willing to exert in order to turn challenging situation into a successful experience.

According to Pajares (1995), perceived self-efficacy influences the amount of persistence and perseverance a person is willing to invest in an activity. People are more likely to engage in tasks about which they feel competent and confident (Pajares, 1995). Pajares also observed that people are more motivated to engage in tasks when they value the outcomes and when they anticipate successful outcomes. However, since people have encountered varying forms and amounts of efficacy-altering experiences, providing new sources of information will not affect everyone equally (Bandura, 1977). People may fear and avoid adverse situations that they feel exceed their coping skills, but readily involve themselves in activities they feel capable of handling. When given appropriate skills and resources, a person's self-efficacy for handling challenging situations increases (Bandura, 1977, 1994). Bandura (1993) asserted that individual efficacy is strongly associated with teacher efficacy, a construct that affects student achievement.

According to Zambo and Zambo (2008), there are two forms of teacher efficacy: *individual efficacy* and *collective efficacy*. Two components of individual efficacy that affect student learning are personal competence and personal level of influence. Personal competence or perception involves a teacher's belief in his or her ability to operate with a high level of proficiency in a specific domain or subject area. Personal level of influence is a teacher's belief about how well his or her actions can influence student learning (Zambo & Zambo, 2008). Collective efficacy involves teachers' collaborations with colleagues within an educational environment. The two components of collective efficacy are group competence and contextual influence. Group competence is the belief that that teachers can work collaboratively at a high level of competence to produce desired learner goals. Contextual influence is the perception of the difficulty of teaching in an educational environment (Zambo & Zambo, 2008). The components of individual and collective efficacy are reflected in the goal of the study and the research questions.

Improvement in teacher efficacy occurs when teachers have social support from colleagues and administrators (Kennedy & Smith, 2014). As mentioned, Rinke et al. (2016) called for professional development to help teachers develop increased comfort and confidence with facilitating STEM instruction across the curriculum. Teacher participation in professional development opens the doors to new instructional strategies and use of curriculum materials (Kennedy & Smith, 2014) and furthermore, improvement in teacher efficacy is directly connected to improvement in student progress (DeChenne, Koziol, Needham, Enochs, 2015; Kennedy & Smith, 2014).

Teachers may need to collaborate with colleagues to obtain full understanding of concepts previously unfamiliar to them (Vangrieken, Dochy, Raes, & Kyndt, 2015). This collaborative social support can lead to better academic planning, goal setting and more diversity in planning lesson activities. According to Vangrieken et al. (2015), teacher collaboration creates increased teacher motivation and self-efficacy for teaching a content area. Mintzes et al. (2013) asserted that teachers who participate in STEM-focused professional learning teams increase their knowledge of mathematics and science and learn more important strategies for developing instructional activities that incorporate those disciplines. Professional development in mathematics may increase teachers' personal competence for integrating mathematics across the curriculum. Hull et al. (2016) discussed two dimensions of teachers' mathematics self-efficacy that affected student learning: interest and enjoyment of mathematics and ability and competence in teaching mathematics. Both dimensions greatly motivated students to learn mathematics and improve students' perceptions about the value and importance of learning mathematics (Hull et al., 2016).

The goal of this study was to explore non-STEM teachers' self-efficacy for integrating mathematics across the STEM charter high school's curriculum. Data were collected via in-depth interviews to gain insight into teachers' background experiences with learning mathematics and to determine how these experiences may influence their self-efficacy for integrating mathematics into their instruction. Based on the data analysis, a project was developed for helping non-STEM teachers strengthen their self-efficacy for integrating mathematics into their instruction.

Review of the Broader Problem

Over the last 35 years STEM education has evolved into a multidisciplinary instructional program that is critical to supporting and developing technological advances which enable the United States to maintain its global competitive status. During the 1980s and the 1990s multiple education agencies and business organizations began to recognize the need for reform and strengthening of mathematics and science education. However, the lack of collaboration among these various agencies and organizations slowed the reform efforts (Kennedy & Odell, 2014). By 2005, funding for STEM initiatives increased due to the belief that China, India and other countries were beginning to surpass the United States in STEM development (Sanders, 2009). By 2016 countries including the United States, Korea, China, and the United Kingdom were involved in increased use of STEM advances to maintain their global competitiveness. There was increased growth in technological and STEM education developments (Yildirim, 2016).

The National Science Foundation (NSF) is one of the leading agencies developing and supporting policies concerning reform in STEM education. Along with support from community college educators and industry partners, NSF sponsored the Advanced Technological Education (ATE) program. The mission of this program is to generate qualified technicians to work in fields that support U.S. economy and security. President Barack Obama applauded the ATE program for contributing to students' success in meeting job market qualifications (Patton, 2014). By 2016 NSF was involved in sponsoring a peer mentoring program for students majoring in science, engineering, or mathematics. The purpose of this program was to assist undergraduates with maintaining STEM college and career paths (Cutright & Evans, 2016).

The nation urgently needs to unite with all stakeholders to effect improvement in STEM education. A 2012 report by the President's Council of Advisors on Science and Technology (PCAST) predicted a deficit of one million STEM college graduates over the next decade. Within the PCAST 2012 report there were recommendations for implementing research courses that would provide beginning college students with opportunities to practice solving challenging problems and to work in teams on authentic projects (Graham, Frederick, Byars-Winston, Hunter, & Handelsman, 2013). College students tended to abandon STEM majors due to boring and sometimes difficult introductory courses. Students need to be engaged in teaching and learning that gives them opportunities to exercise their creative thinking and problem-solving skills (Graham et al., 2016). Strengthening the STEM workforce is critical to the United States maintaining its global competitiveness (Baber, 2015; Kennedy & Odell, 2014; Koehler & Bloom, 2015).

Some school districts still advocate teaching of the four STEM disciplines with traditional pedagogical approaches. This means each subject is taught in insolation with little or no planning toward integrating these subject areas (Kennedy & Odell, 2014). However, many other districts have adopted integrative approaches for teaching the STEM disciplines, considering them as one cohesive entity. Using the integrative approach for STEM instruction parallels how STEM professionals in the work world apply STEM content knowledge and skills. For example, engineering design combines science, technology, engineering and mathematics concepts to create many of the products and services currently used and needed today (Kennedy & Odell, 2014).

STEM Literacy

In the 21st century, STEM literacy should be an educational priority for all students, as it will enable them to become more knowledgeable about the environmental and economic issues that currently impact society (Bybee, 2013). Becoming STEM literate is the beginning step for motivating and preparing students to enter the STEM workforce. The knowledge and skills embedded in the study of the STEM disciplines form the basis for designing and creating many of the technological and scientific advances that are now vital to our personal, societal and economic needs (Bybee, 2013).

According to the Programme of International Student Assessment (PISA), *Mathematical Literacy* (also called numeracy) is the ability to formulate, apply and interpret mathematics in a variety of real world contexts (PISA, 2015). Turner (2014) discussed how mathematical literacy can be applied to real world situations. According to Turner (2014), becoming mathematically literate enables students to: communicate using mathematical language and ideas to build and support problem solutions;

mathematise real world problems by creating mathematical models with the use of a variety of mathematical representations such as graphs, tables, charts and/or equations; reason mathematically by reflecting on the mathematics knowledge and skills applicable to the context of the situation; think critically while planning and designing a sequence of mathematical problem-solving steps; and identify and use appropriate mathematical tools, such as computer-based applications, calculators and/or measuring instruments to generate problem solutions. These literacy applications are reflective of the Standards of Mathematical Practice which accompany the Common Core State Standards for Mathematics. The Standards of Mathematical Practice contain eight principles related to mathematics conceptual understanding, reasoning, and problem solving (2016 Common Core State Standards Initiative). Teachers in the school associated with this study are now expected to utilize the Common Core State Standards.

Supporting STEM literacy in the classroom involves: teaching STEM content with an integrated approach, placing emphasis on applying content knowledge and skills via investigation and analyzation. Student interest in STEM can be stimulated by providing learning experiences that build students' confidence and ability to solve problems related to STEM content and providing opportunities for students to operate with STEM technologies efficiently (Nurlaely & Riandi, 2017). According to Nurlaely & Riandi (2017), STEM literacy encompasses the three domains of learning: cognitive, affective, and psychomotor. The cognitive domain involves knowledge processing. Cognitive understanding occurs when students can decode, conceptualize and apply academic content. The affective domain involves students' attitudes and beliefs. When teachers create a learning environment that fosters self-determination, cultivates self-regulation, emphasizes collaborative social goals and establishes engaging learning activities, students feel confident and competent about STEM learning. The psychomotor domain involves the development of competency with manual and physical skills that are needed to operate and use precision instruments and tools.

STEM Education

STEM education is a multidisciplinary area of study that connects the four disciplines of science, technology, engineering, and mathematics (Yildirim, 2016). Bybee (2013) suggested the context (e.g., national policies, state standards and assessments, school programs, classroom practices, etc.) with which education stakeholders identify, clarifies the meaning of STEM education. Education stakeholders' points of view determine the meaning they apply to STEM education. Bybee also asserted STEM education should address global challenges, environmental concerns, 21st century workforce skills, and related national security issues.

Foundations of STEM education should begin in elementary school, when students are first formally introduced to mathematics and science concepts (Watters & Diezmann, 2013). In addition student interest in STEM fields should be developed throughout their K-12 education experience. Exposure to STEM concepts during the beginning elementary years positively influences students' awareness and attitudes about learning STEM content, thus they may be motivated to enroll in more advanced STEM courses during their middle and high school years (Daugherty, Carter & Swagerty, 2014). Quality learning experiences related to STEM content during the high school years positively influences students' decisions to enter STEM degree programs, which can prepare them for STEM focused careers.

According to the 2016 Common Core State Standards Initiative, forty-two states and the District of Columbia have adopted the Common Core State Standards for English Language Arts and Mathematics These standards emphasize developing cognitive strategies such as, problem formulation (students formulate a problem, generate hypotheses and possible strategies to solve the problem), research (students collect information to solve problems and identify relevant resources related to the problem), interpretation (includes outlines of key points related to a problem), communication (organization, construction, analyzation and presentation of research), and precision and accuracy (adhering to the academic rules associated with the various disciplines). The Common Core State Standards (CCSS) define the knowledge and skills K-12 learners need to succeed in entry level college courses and workforce training programs which lead to future careers (Eubanks, 2014). The Common Core State Standards for Mathematics (CCSSM) call for practice in applying mathematical ways of thinking to real world problems. Mathematical proficiency is essential to students' development of proficiency with skills associated with science and engineering (Akkus, 2016). The Standards of Mathematical Practice connect to the standards of mathematics content found in CCSSM and emphasize the processes and proficiencies that are critical to learning and understanding mathematics. The first four of these mathematics practice standards are the National Council of Teachers of Mathematics (NCTM) process standards of problem solving, reasoning and proof, communication, and representations and connection (2016 Common Core State Standards Initiative). These process standards can be applied to other academic disciplines to assist students with applying mathematics across the curriculum (Akkus, 2016), and could support non-STEM teachers with developing instructional activities that utilize mathematical ways of thinking, such as analyzing situations related to course content, building logical steps and evidence to support problem solutions, or writing explanations of solutions in the context of real-world problem situations. The process standards' constructs included in the Standards of Mathematical Practice have been identified as the essential criteria for STEM integration classroom practices (English, 2016).

The Framework for K-12 Science Education is a standards document that outlines approaches to science education (Lee, Quinn & Valdes, 2013). An associated document entitled Science and Engineering Practices, is connected to the New Generation of Science Standards, and aligned with the Standards of Mathematical Practice. Both documents emphasize the importance of students engaging in problem solving, using mathematics concepts and modeling for building and designing explanations and solutions in the context of real world experiences. The alignment between these documents supports an integrative approach to teaching STEM content, which should not be taught in isolation, but as one cohesive entity, because they have similar learning processes and proficiencies and applications that can connect concepts across the curriculum (Lee, Quinn, & Valdes, 2013).

Educational Pathways

Consultants and entrepreneurs have created many STEM initiatives aimed at implementing effective STEM instructional programming. These initiatives are supported by foundations, professional organizations, universities, publishers of educational materials, and school systems (Andree & Hansson, 2014). Inclusive STEM High schools, similar to the local STEM high school in this study, have emerged across the United States with the ultimate goal of improving STEM education (LaForce et al., 2016). According to LaForce et al. (2016), there are eight essential elements need by these schools to maintain a successful STEM instructional program. These elements include: problem-based learning (students make interdisciplinary connections and are involved in problem-solving projects); rigorous learning (Students engage in real-world content); personalization of learning (differentiated instruction based on learners' needs); career technology and life skills (students have opportunities to participate in early college activities and workplace skills using new and current technologies); school community and belonging (students exposed to a positive social and emotional learning environment); staff foundations supporting (teacher collaboration, common planning time, and engagement in professional development); and essential factors supporting (staff open to change; family involvement; online management system). Education pathways should be well designed to connect to academic content of major subject areas such as mathematics, English, science and social studies, as well as world languages and the arts (LaForce et al., 2016).

Linked Learning, a STEM initiative creates pathways that prepare students for college and career success. Core academic content is connected to such professional fields as engineering, law, and the performing arts. (Rogers-Chapman & Darling-Hammond, 2013). Another example of a STEM initiative is Project Lead the Way (PLTW), a program with a problem-based curriculum designed to improve STEM education and which is considered one of the largest providers of middle and high school STEM programs. Its major objective is to prepare students to successfully navigate STEM college pathways leading to STEM-related career fields. UNITE, a STEM enrichment program sponsored by the Army Educational Outreach Program, offers innovative, hands-on activities primarily to minority students. A 3D-printed Rover Workshop was sponsored by the Army UNITE 2017 summer program held at Jackson State University gave student participants opportunities to assemble and program mobile robots (Hsiung, Deal, & Taluri, 2017).

Integrated STEM Education

Many advocates of STEM education believe the STEM subject areas are best taught with an integrative approach, which can involve interdisciplinary teaching and learning between STEM subject areas and non-STEM subject areas (Moore & Smith, 2014). The interrelationships between the subject areas are clarified as students engage in learning experiences that utilize formal, specialized and applicative knowledge of each of the subject areas to solve problems (Moore & Smith, 2014). STEM integration connects the four core STEM disciplines of science, technology, engineering and mathematics into one cohesive course, unit or lesson that includes real-life applications. Students have opportunities to apply their mathematics and science learning to solve problems that require engineering design with use of appropriate technologies (Moore & Smith, 2014).

English (2016) asserted that the design for integrative STEM takes on the perspectives of multidisciplinary, interdisciplinary, transdisciplinary teaching and learning approaches. The multidisciplinary approach refers to core concepts and skills of subject areas being taught independently, but with a common theme. The interdisciplinary approach refers to teaching and learning between two or more subject areas, while the transdisciplinary combines knowledge and skills of two or more disciplines and applies them to solve real-world problems and the construction of STEM projects. Johnson, Peters-Burton and Moore (2016) suggested three forms of classroom STEM integration: content integration, supporting content integration, and context integration. Content integration involves lesson activities that have multiple STEM learning objectives. Supporting content integration involves one STEM content area's objectives being covered to support another STEM content area's learning objectives. Context integration refers to the use of a context related to one STEM discipline to establish teaching and learning in another STEM discipline. The design of interdisciplinary STEM lesson activities should include real world problem solving that incorporates engineering design along with appropriate technologies. These lesson activities should be supported with standards-based mathematics and science applications as well as content from other disciplines, such as English/language arts and social studies (Moore, Johnson, Peters-Burton & Guzey, 2016).

The integrative approach to teaching the STEM content areas fosters increased interest in mathematics and improves students' attitudes about mathematics learning and its real-world applications. Mathematics educators have found evidence that the use of integrative teaching approaches among STEM subjects leads to more successful mathematics learning (Kertel & Gurel, 2016). Integrative approaches improve students' interest in STEM learning and create a strong STEM knowledge foundation to prepare them for college and career goals related to STEM. However, integrative approaches require close collaboration and commitment among teachers, as well as support from administrators. Teachers have different beliefs and perceptions about how to implement STEM integration in the classroom (Bryan et al., 2016; Ruggirello & Balcerzak, 2013). Teachers' classroom practices in relation to STEM integration are influenced by their perceptions of the integrative design approaches, school context, administrative support, and educational trends in national curricula and standards requirements (Ruggirello & Balcerzak, 2013).

Teachers of art and music are often overlooked by educational researchers studying STEM. However, STEM content is embedded in each of these subject areas. Art teachers suggest the STEM acronym be changed to STEAM, to include the arts as a part of the STEM curriculum. Art is embedded in the creative process associated with engineering design. Visual arts teachers incorporate functional design as a part of their curriculum. Functional design involves the aesthetic nature of the design process, which can be displayed in products, environments, and graphic design. (Guyotte, Sochacka, Costantino, Walther & Kellam, 2014). Digital art involves applications of technology. The introduction of computers has brought about an increase in the adoption of new digital technologies by educators of the arts. It connects course work to the lived experiences of students. Use of digital technologies stimulates students' imaginations and creative processes (Keane & Keane, 2016). The latest -12 music education software develops students' music compositional skills (Nielsen, 2013). Music course content contains many mathematics applications related to theory and composition. Musical elements such as rhythm, tempo, and melody, contain embedded mathematical principles such as spatial properties, sequencing, counting, patterning, and one-to-one correspondence (Trinick, Ledger, Major & Perger, 2016).

Professional Development in STEM

Professional development and support is essential to prepare and qualify teachers to facilitate STEM instruction. When teachers are provided with strategies and resources related to integrating STEM content across the curriculum and across grade levels, it increases their efficacy and comfort for teaching STEM content. It is critical to address the limitations that elementary teachers may have with STEM content because students' STEM foundation knowledge is formed during the early years of their education (Nadelson et al., 2013). However, middle school teachers may also have limitations in

STEM content areas and may need support. Since students' levels of academic performance often decline during the middle school years, teachers at this level must be able to create high levels of student engagement and achievement in STEM learning by involving student in creative and authentic learning experiences (Nadelson et al., 2013).

Researchers agree that STEM professional development should include STEM content knowledge, training with inquiry-based instruction, scientist-teacher partnerships, professional STEM organization and school partnerships, opportunities for teacher collaboration in professional learning teams, and focus on integration of STEM across the curriculum, on all levels K-12 (Avery & Reeve, 2013; Nadelson et al., 2013). Recommendations for how teachers can become proficient facilitators of integrated STEM instruction have led to the establishment of multiple professional development programs specifically focused on STEM teaching and learning. Examples of these programs include: SySTEMic Solution, a professional development program for teachers of Grades 1-5, which began with a 3-day summer institute focused on inquiry-based STEM (Nadelson, Callahan, Pyke, Hay, Dance & Pfiester, 2013); the i-STEM institute, a week long intensive professional development program during which K-12 educators participated in STEM-related activities that included energy and robotics (Nadelson, Seifert & Hendicks, 2015); STEM TIPS, a program enacted to support beginning secondary STEM teachers. STEM TIPS employs a mobile platform design to provide customized mentoring for teachers via web-based resources (Jones, Dana, LaFramenta, Adams, & Arnold, 2016); and MSUrban STEM Fellowship program which provides outstanding urban STEM teachers with opportunities to engage in instructional and leadership experiences (Horton, Shack & Mehta, 2017).

Since the beginning of the 21st century, the role of Project Based Learning (PBL) has become more prominent in STEM education (Han, Yolvac, Capraro & Capraro, 2015). STEM Project based learning involves multi-disciplinary lesson activities during which students identify problems and problem solution strategies (Han et al., 2015). Wan Husin, et al. (2016) discussed Project-Oriented Problem Based Learning (POPBL) which involves inquiry based learning, problem based learning and project based learning. Students develop 21st century workplace skills as they solve real world problems in the context of project work. Use of POPBL enables students to develop the effective communication and critical skills needed to produce innovative, high quality products (Han et al., 2015; Reeve, 2014; Wan Husin et al., 2016).

Many STEM professional development programs and initiatives place emphasis on the development and implementation of Project Based Learning as the instruction approach needed to provide quality student STEM lesson experiences (Han et al., 2015; Reeve, 2014; Wan Husin et al., 2016). Sustained professional development is necessary to enable teachers to successfully implement Project Based Learning in their classrooms (Han et al., 2015). Teachers must increase their knowledge about STEM areas and how they connect to the real world (Reeve, 2014). Reeve (2014) posits teacher collaboration is necessary to design and implement well-defined integrated STEM courses and lesson activities. Project based learning experiences promote increased student achievement and motivation for selecting STEM college and career paths (Han et al., 2015; Wan Husin et al., 2016).

Search Strategy

Prospective, peer-reviewed articles and books that contained information relevant to my study were identified using the following databases: (a) ERIC, (b) Google Scholar, (c) ProQuest Central, (d) Sage, and (e) Taylor and Frances Online. Current articles (within 5 years of the study completion) and classic articles by such authors as Bandura, Pajares and others were used to generate a body of literature that aligns with the conceptual framework and problem associated with my study. I used Boolean operators, AND OR to optimize the search results. The articles' abstracts were used to judge their relevancy to the study's problem, conceptual framework, and research questions. Reference lists of selected articles were searched to identify additional articles that could possibly inform this study. The literature reveals the key components of STEM education relevant to the problem referenced in this study, including recommendations for how to facilitate quality STEM instruction across the curriculum for the elementary, middle and high school levels. Elements of quality STEM education programs and the types of partnerships needed to sustain those programs is also discussed throughout the literature reviewed as well as the kind of professional development that has been created to address the problem.

The following keywords were used in the search fields to generate resources and information relevant to the study: integrated STEM Education, self-efficacy, STEM literacy, STEM education and teacher efficacy. These keywords were researched initially as single topics and secondly within the use of the following Booleans: **STEM Education** and (STEM literacy, interdisciplinary instruction, teacher efficacy, mathematics instruction, self-efficacy, teacher efficacy, integrated instruction, numeracy, technology, engineering, science instruction, student achievement, professional development, Common Core Standards); **Integrated STEM Education** and (technology, engineering, mathematics instruction, self-efficacy, teacher efficacy, professional development, the arts, student achievement).

When selecting articles for the literature review, my primary focus was the local problem of non-STEM teachers' inability to effectively integrate mathematics into their disciplines. My secondary focus was the significance of the local problem to the broader setting of the national concern for increasing the number of qualified people who can fill positions related to STEM fields. My research revealed numerous articles covering many facets of STEM education. I selected those that best addressed the issues related to STEM integration across the curriculum and to teacher self-efficacy. The proposed project study is designed to address non-STEM teachers' self-efficacy for integrating mathematics across the STEM charter high school's curriculum.

Implications

Based on the literature review, I anticipated that I would need to develop a project that provided an intervention to help non-STEM teachers with integrating mathematics across the curriculum. Interviews with non-STEM teachers to achieve a deeper understanding of their self-efficacy led to the development of supports that customize selected strategies and resources to individual teachers' subject areas. The study revealed insights into which factors of teacher self- efficacy influence the implementation of integrated STEM instruction.

This project study investigation indicated a need for the development of interdisciplinary teacher teams to create authentic student project experiences that use multidisciplinary course content and skills. Such projects can help increase student achievement and contribute to their preparation for engagement in STEM career fields. Results of this study generated classroom practices that can be applied to other STEM school environments that may be experiencing similar problems.

Summary

This study reflects the growing importance of STEM education to society as well as the current thrust to integrate STEM content across the curriculum on all levels including K-12 and post- secondary. The study's focus was on a local school problem involving non-STEM teachers' self-efficacy for integrating mathematics into their instructional activities. It is important that K-12 educators be prepared to teach STEM-related content skills to prepare students for the 21st century job market. The literature review highlighted the importance of understanding mathematics in relation to developing students' interest in pursuing STEM-related college and career fields. Strengthening the STEM workforce is vital to keeping the United States globally competitive. The review also covered multiple STEM initiatives and programs that provide professional development training and support for teachers which would enable non-STEM teachers to integrate STEM content into their content areas. The remaining sections of this study cover the methodology for the study, data collection and analysis.

Section 2: The Methodology

Qualitative Research Design and Approach

A qualitative research design was chosen for this study because the focus was on participants' perceptions of self-efficacy for integrating mathematics across the STEM charter high school's curriculum. I sought a deep and nuanced understanding of non-STEM teachers' views of their individual motivation, persistence, perseverance, competence, and confidence in their attempts to honor the requirements of the school leadership. Qualitative research involves the development of an in-depth understanding of how people interpret their worlds as well as what meaning they attribute to their experiences (Merriam & Tisdell, 2016). The conceptual framework underpinning this study was self-efficacy theory (Bandura, 1994). Self-efficacy affects teachers' confidence for developing lessons that relate to students' prior learning and life experiences (Bandura, 2007; Hoy & Spero, 2005).

During the study investigation, I explored the components of self-efficacy (motivation, persistence, perseverance, competence, and confidence) in relation to the local school's non-STEM teachers' self-efficacy for integrating mathematics into their instructional activities. High levels of teacher efficacy lead to high expectations for student success and increased student achievement (Bandura, 1993; Pajares, 1995; Peebles & Mendaglio, 2014).

Since the study's focus was on a specific group of teachers in a single educational setting it can be classified as a case study (Merriam & Tisdell, 2016; Yin, 2014).

According to Yin (2014), a case study focuses on a specific entity (in this case an educational organization), a group associated with that organization and an activity associated with the organization. The study findings are bounded by the perspectives of one group of non-STEM teachers who teach in one STEM charter high school. The group of study participants consisted of non-STEM teachers who work at the study school and who were challenged with integrating mathematics into their instruction. A case study is usually a qualitative design that involves a detailed study of a specific group within a specific environment. The focus was on the individual perspectives of the members of the group and how they attached meaning to or feel about a particular situation (Yin, 2014; Merriam & Tisdell, 2016).

The qualitative case study research design was the most appropriate research design for this study. Other qualitative designs were not applicable. A phenomenological design was not applicable because its emphasis is on the individual participant's views of lived experiences, rather than the shared experiences related to the problem situation (Merriam & Tisdell, 2016). An ethnographic study design was not applicable because its concentration is on the culture of the group or the individual members of the group. An ethnographer would look at how cultural aspects affect the problem situation under study (Merriam & Tisdell, 2016). A grounded theory study design was not because the goal of the study was not centered on establishing or developing a theory based on the data collected (Merriam & Tisdell, 2016).

Quantitative research designs are not applicable to this study because numeric or statistical data would not provide answers to my research questions. Moreover, the goal was not to prove or disprove a hypothesis, and the data collection process was inductive rather than deductive. Data were collected through personal interviews. Quantitative research is based on mathematical analysis of the data, whereas qualitative research is based on analysis of the transcripts and notes generated by interviews and observations (Creswell & Creswell, 2018).

Participants

Study participants were non-STEM teachers who worked at the public charter high school selected for the study. There were sixteen non-STEM teachers on staff at the local school. All sixteen of the non-STEM teachers were invited via personal communication and written letter to participate in the study. Twelve of these teachers agreed to participate in the study. The letter included the purpose of the study, information about maintaining confidentiality and protection of participants, and data collection procedures, including the approximate amount of time needed by participants to complete each procedure. Participation in the study was strictly voluntary. I approached each potential study participant individually to request his or her participation in the study. The names of the participants, as well as the name of the school have been kept confidential. Data were collected from each participant via individual interview and was not shared with any other study participants or any individuals outside of the project study. Collected data are stored in a secure place at my home and will be kept for at least five years.

Since I previously worked as a teacher in the same educational environment as the potential participants, gaining access to these participants was not difficult. I contacted the Head of School and requested an appropriate time for meeting with potential study participants to distribute the letters inviting them to participate in the study. Upon receiving teachers' consent to participate in the study, I contacted them individually via phone or email to arrange interview times and appropriate meeting locations. Having already established rapport with potential participants as a co-worker made the researcher-participant relationship easy to establish because a trustworthy, professional relationship was maintained with them during my tenure at the local school.

Prior to the interviews, study participants were given consent forms, which they signed and returned within a specified period, via email or other process. Consent forms contained the title and purpose of the study, an outline of participant's rights, the protection of their rights, and data collection procedures. Participants were advised that they could withdraw from the study at any time, have the right to ask questions prior to participating in the interview or during the interview, and could have access to the findings generated by the study after the research is completed.

Data Collection

Upon receiving IRB approval and study participants' consents I proceeded with the data collection process. Walden University's IRB approval number for this study was

04-06-17-0291282.   Data were collected from study participants via personal interviews. According to Yin (2014), interviews provide participants' personal views and perceptions and a deeper understanding of study problem. Interview questions were open-ended and informed the research study questions (Creswell & Creswell, 2018). Data collection instruments include interview questionnaires and protocols (see Appendices C and D). Interview protocols will be utilized to record information during the interviews (see Appendix D). According to Creswell and Creswell (2018), qualitative data should be recorded with the use of researcher-designed protocols to facilitate data organization. The interview protocols used for this study will be researcher produced. These documents were reviewed by non-study teachers and my doctoral committee for clarity and alignment. Interview questions were provided to participants prior to the times of the interviews. This enabled participants to have opportunities to think about their responses and the types of information they would like to contribute during the interviews. Participants felt more relaxed and comfortable about the interview process because they knew what to expect during the time of the interview. The following table shows how the interview questions related to the constructs of self-efficacy.

Table 1

Self-Efficacy Constructs and Related Interview Questions

Construct	Related Interview Questions
Confidence	What personal background experiences with learning mathematics have had an influence (positive or negative) on your sense of confidence when it comes to integrating mathematics into your instruction?
	How would collaborating or team teaching with a mathematics teacher affect your sense of confidence when it comes to integrating mathematics into your instruction?
	Has professional development on integrating mathematics across the curriculum increased your sense of confidence when it comes to integrating mathematics into your instruction? Why or why not?
Competence	How would collaborating or team teaching with a mathematics teacher influence your competence for integrating mathematics into your instruction and into your course content?
	How can professional development on integrating mathematics across the curriculum increase your competency for integrating mathematics into your lesson activities?
Motivation	How does teaching in a STEM educational environment influence your motivation for integrating mathematics into your instructional activities?
	How would team teaching or collaborating

	with a mathematics teacher affect your motivation for integrating mathematics into your instruction and/or course content? How do you value mathematics as a subject area needed in real life and how does this influence your motivation for integrating mathematics into your instruction?
Perseverance	What factors (positive or negative) influence the frequency with which you integrate mathematics in to your instruction? If you repeatedly tried to integrate mathematics applications into your instruction without positive results (i.e. students are still unable to correctly apply the math concepts to the lesson), what would you do?
Persistence	What factors are needed in professional development sessions on integrating mathematics across the curriculum to influence your persistence with integrating mathematics into your instruction? How would collaborating or team teaching with a mathematics teacher help overcome problems you may encounter with integrating mathematics into your instruction and influence your persistence with integrating mathematics into your course content?

Probes were used to clarify or expand interview responses to gain accurate interpretation of participants' perspectives (Creswell & Creswell, 2018). The interview protocols were utilized to keep the interview process organized and conducted in a timely manner. Interview responses and researcher reflections were chronicled on the protocol forms. With a study participant's permission, interviews were also audio-taped to ensure accuracy of the information to be utilized during the data analysis' process. The audio-taped interviews were transcribed as soon after interview as possible. Data were organized and filed according to the type of data generated: interview protocol notes and transcribed notes. A research log was kept that contains the dates and times of scheduled interviews. Interviews were scheduled primarily during participants' planning periods or after school hours. Interviews were held in a conference room, or at an off campus location of the teacher's choice.

Gaining access to study participants was not difficult because I previously worked at the local school as a full-time classroom teacher. I recently retired from the local school in June 2016. During my tenure at the local school, I worked as a mathematics teacher and served as mathematics resource coordinator. In this role, I was charged with providing strategies and resources for integrating mathematics across the curriculum to non-STEM teachers. I also facilitated professional development sessions on integrating mathematics across the curriculum for the local school's faculty. Although I had opportunities to discuss mathematics integration individually with potential study participants, my personal communications with them only established strategies for connecting mathematics to specific lessons or topics they were engaged in at the time. I acted as their mentor not as a supervisor or evaluator. My personal communications with potential study participants did not involve in-depth conversations about their self-efficacy for including mathematics in their lesson activities.

Data Analysis

For this study, data analysis was on-going. Study participants' interview responses generated information that was coded and organized into themes that informed the study findings. Miles, Huberman and Saldana (2014) defined codes as labels that categorize segments of data to inform the research questions and study constructs. According to Creswell (2012), themes are similar codes which can be clustered together to represent main ideas generated from the data. Miles et al. (2014) identified similar codes as pattern codes which identify emergent themes. Themes emerged that center around non-STEM teachers' levels of efficacy for integrating mathematics into their disciplines. These themes created links between the data categories that informed the research questions (Dey, 1993; Miles, et al., 2014). Codes and themes developed from the data have been used to organize the data into appropriate tables and matrices. Graphic organizers can help build clarity among the relationships between the study variables and ultimately help establish credible study findings (Dey, 1993; Miles, et al., 2014).

Yin (2014) suggested four general strategies for analyzing case study evidence: relying on theoretical propositions, working the data from the ground up developing case descriptions, and examining rival explanations. Relying on theoretical propositions is most applicable to this study. The theoretical concept shaping this study is self-efficacy, which is reflected in the study's problem, purpose, research questions and literature review. Prior to conducting the fieldwork, preliminary codes were created by utilizing the constructs of the conceptual framework (Miles et al., 2014). Preliminary codes considered for this study included the self-efficacy constructs of confidence, competence, motivation, perseverance and persistence. Interview questions were designed to access information regarding participants' self-efficacy. The study participants' interview transcripts were reviewed for key phrases that reflect their levels of self-efficacy for integrating mathematics into their instructional activities. It was necessary to conduct subsequent interviews with some study participants to probe for clarity and a deeper understanding of their responses. Ultimately, themes were developed from the identified codes to inform solutions to the research questions.

The data were organized using the interview questions, then by codes and themes that emerged from the data. For example, the question, "How would collaborating or team teaching with a mathematics teacher affect your confidence for integrating mathematics into your instructional activities?" elicited the following answer from one of the participants:

> "It would definitely be my source of confidence. The closest I've come to integrating math in my classes is with map study and map scales. I definitely need a math teacher to lean on"

This response was assigned the following codes:

Confidence (self-efficacy) – this teacher does not seem confident about integrating mathematics into his or her instruction.

Competence (self-efficacy) – the teacher needs to feel that the collaborator is competent in his or her own field and that the advice he may receive will be useful and valuable.

Qualitative data collection and analysis is meant to be exploratory. Codes and themes will arise that may not have been previously reviewed in the study. According to Yilmaz (2013), qualitative data have fundamental characteristics that offer advantages over quantitative data. Qualitative data captures participants' in-depth perspectives and experiences in relation to a phenomenon, whereas quantitative data reveal outcomes and generalizations. The qualitative approach offers answers to questions that may not be asked (Yilmaz, 2013). Emergent codes and themes contributed to the understanding of self-efficacy as it was perceived by the non-STEM teachers that were interviewed.

Data analysis helps the researcher build a comprehensive description of the study problem. A quality interpretation, explanation and understanding of the data can be developed based on the data analysis. Qualitative analysis centers around related processes of describing participants' experiences, classifying the related data, and linking the related data concepts (Dey, 1993). Strategies for ensuring the credibility of this study involved the utilization of member checks, adequate engagement in data collection, researcher reflexivity, peer reviews, and external auditor reviews. Member checking allowed participants to check the accuracy of preliminary study findings. Individual preliminary study findings were made available to each study participant. Participants critiqued the accuracy of their own data to ensure accurate interpretation of their interview responses prior to completion of the final study report. According to Merriam and Tisdell (2016), adequate engagement in data collection involves spending enough time on site to collect the data and purposely looking for discrepant cases. Researcher reflexivity involves a self-examination by the researcher for biases and experiences that may influence data interpretation (Merriam & Tisdell, 2016).

The use of a peer reviewer (a non-study teacher) involves having the raw study data scanned by a colleague, who is familiar with the topic, for accuracy of interpretation of the findings (Creswell & Creswell, 2018). The peer reviewer for this study is a mathematics teacher with 15 years of experience who has no connection with the local school or potential study participants. The peer reviewer currently works at another charter school in the district. An external audit involves the use of an independent researcher to examine all the data for clear connections between the data and study findings for the purpose of establishing support for the researcher's interpretations of the data and to check for control of the researcher's biases (Houghton, Casey, Shaw & Murphy, 2013; Creswell & Creswell, 2018). The external auditor for this study holds a doctorate degree in administration and a master's degree in mathematics. The external auditor is a professional consultant who has no connection with the local school. The purpose of these reviews was to check for logical development of themes in the study findings.

When reporting study findings, the researcher must avoid analytic biases. Miles et al. (2014) identified four of these biases: *Holistic fallacy* – interpreting events as more patterned and congruent than they really are; *Elite bias* – overweighting data from well-informed, usually high status participants and underrepresenting data from less informed participants; *Personal bias*- allowing the researcher's personal agenda or personal "axes to grind" to skew the ability to represent data analysis in a credible manner; *Going native* – researcher losing his or her perspective and being drawn into the perceptions and explanations of local participants. When developing the final report for this study, these researcher biases were avoided: by carefully reviewing the text of the data more than once to get an overall sense of the findings by considering all participants' responses as equally important (not over-depending on one participant's views); by keeping an open mind about participants' perspectives and not letting my opinion color the interpretation of the findings; by staying focused on research questions as interviews are conducted; and by having a peer reviewer look at interview notes and researcher reflections (Miles et al, 2014). Miles et al (2014) also identified five standards for quality conclusions that should be utilized when developing and reporting the findings of qualitative research. For this study the following standards were met:

1) Objectivity/confirmability – generating a complete picture of the study phenomena; keeping detailed records of methods and procedures- auditable, if necessary for re-analysis by others; forms of peer or colleague review are in place.

2) Reliability/dependability – research questions clear and aligned with study focus; findings show parallelism across data sources (participants, contexts, times);
3) Internal validity/credibility/authenticity – findings are plausible; an authentic portrait of the data has been developed; triangulation among complementary methods and data sources produce converging conclusions that are considered accurate by original participants.
4) External validity/transferability/fittingness study is useful in other settings.
5) Utilization/application/action orientation findings useful for participants.

The final report for the study will be in the form of a narrative discussion that includes the study findings and possible directions for development of the project.

Data Analysis Results

Data Collection Process

Non-STEM teachers who are a part of the local school's faculty were personally invited to participate in the study via letters of invitation. The letter of invitation identified the researcher, the researcher's contact information, a brief discussion about the purpose of the study and procedures for participating in the study. Emphasis was placed on the voluntary nature of the study a long with an explanation of the risks and benefits related to study participation. Each potential participant received a consent for which contained the purpose of the study, an outline of study procedures, sample interview questions, the voluntary nature of the study, the risks and benefits related to participating in the study, and procedures for protection of participants' privacy. The researcher's contact information was also included in this form as well as the Walden University's contact information and approval number for the study. Sixteen non-STEM teachers were invited to participate in the study. Twelve of these teachers agreed to participate in study. The twelve study participants included four English teachers, four social studies teachers, one Spanish teacher, one art teacher and two special education teachers.

Upon receiving a signed consent form from a potential study participant, a date and time was established for an interview with the participant. Data for the study were collected via personal interviews and audio recorded via cell phone. Prior to the interviews, the study participants received copies of the interview questions to encourage participants to be reflective of the information they would like to include in their interview responses. Interview transcripts were generated from the recordings. Data from the transcripts were carefully reviewed to identify themes and codes related to the study.

Findings

Based on the conceptual framework of self-efficacy and the study participants' interview responses themes and codes were identified to organize and categorize the data. The local school's non-STEM teachers' interview responses generated the following data in relationship to the themes and codes developed from the data.

Theme: Teacher Efficacy

This theme is based on the following codes: confidence, competence, motivation, perseverance, and persistence.

Confidence. Non-STEM teacher interviewees indicated that their confidence for integrating mathematics into instruction would increase when they have:

- Experienced positive personal experience with learning mathematics.
- Opportunities to collaborate and team teach with a mathematics teacher.
- Opportunities to observe a mathematics teacher's instruction
- Opportunities to participate in professional development that provides examples of how to integrate mathematics applications in to their specific subject areas and can engage in practice with creating lesson activities that involve mathematics integration.

Successful experiences support and strengthen personal efficacy beliefs (Bandura, 1993, 1994). Improvement in teacher efficacy occurs when teachers have social support from colleagues (Kennedy & Smith, 2014). Observing social models who exhibit competencies to which others aspire can inspire people to believe that they personally are capable of managing difficult tasks and producing successful outcomes (Bandura, 1994). Rinke et al. (2016) asserted professional development assists teachers with developing increased comfort and confidence with facilitating STEM instruction across the curriculum.

Competence. Non-STEM teacher interviewees indicated that their competence for integrating mathematics into their instruction would increase when they have:

- Opportunities to collaborate or team teach with a mathematics teacher.
- Opportunities to observe a mathematics teacher's instruction.
- Opportunities to engage in professional development sessions that provide a review of basic mathematics concepts, course-specific activities for integrating mathematics into their subject areas and resources for integrating mathematics across the curriculum.

Collective efficacy involves teachers' collaboration with colleagues within an educational setting. Teachers can work collaboratively to develop a high level of competence that will result in production of desired learner outcomes (Zambo & Zambo, 2008). As mentioned before, observing social models who exhibit competencies to which others aspire can inspire people to believe that they personally are capable of managing difficult tasks and producing successful outcomes (Bandura, 1994). STEM professional development should include teacher collaboration in professional learning teams, STEM content knowledge, and a focus on integrating STEM across the curriculum (Avery & Reeve, 2013; Nadelson et al., 2013).

Motivation. Teaching in a STEM environment does not necessarily motivate the local school's non-STEM teachers to integrate mathematics into their lesson instruction.

- Some of the teacher interviewees felt that there needs to be more information shared in regard to the STEM instruction that is offered in the school's STEM

- courses, so that they can better help students make connections between the non-STEM and STEM courses.
- Non-STEM teacher interviewees said they would have increased motivation for integrating mathematics into their instruction if they could collaborate or team teach with a mathematics teacher, and if they could observe mathematics teacher's instruction within the mathematics class.
- Non-STEM teacher interviewees felt that mathematics is very valuable in real life in regard to everyday life skills, such as balancing a checkbook, calculating percentages, money management, making informed consumer decisions, etc.
- Only a few of the teacher interviewees recognized the importance of learning mathematics in preparation for securing a STEM career or entering lucrative, high-tech job market. Only one teacher mentioned the value of developing reasoning and problem-solving skills.

Bandura (1977 and 1994) asserted that self-efficacy beliefs determine perceptions of self- motivation and behavior in relation to particular circumstances. Teachers with high levels of efficacy are motivated to use more innovative strategies and approaches for designing student learning experiences (Bandura, 1993; Pajares, 1995; Peebles & Mendagleo, 2014).

Perseverance. Most of the interviewees said they wanted opportunities to collaborate with a mathematics teacher and/or consultant who can identify specific areas in their course content that relate to mathematics. Then they would be willing to integrate mathematics into their instruction more frequently.

- In general, interviewees felt that a mathematics application must fit into the course content that they are required to teach and that this is what would drive the frequency with which they would consider integrating mathematics into their instruction.
- Some teachers mentioned being under time constraints to cover course content.
- Interviewees said if they tried to integrate mathematics applications into their instruction without success they would consult a mathematics teacher or consultant about ways to improve their instruction, change their approach to the lesson based on students' learning styles, and/or consider student peer tutoring to help students better understand the lesson concepts.

Bandura (1997) asserted that efficacy expectations determine the amount of effort and persistence a person is willing to exert in order to turn challenging situations into successful experiences. Teachers may need to collaborate with colleagues to obtain full understanding of unfamiliar concepts (Vangrieken et al., 2015). Collaborative social support creates increased self-efficacy for teaching a content area. Teachers with high levels of self-efficacy demonstrate more perseverance and persistence with helping students to succeed (Milner & Hoy, 2003).

Persistence. Interviewees said that they would be more persistent about integrating mathematics into their instruction if they:

- Had opportunities to engage in professional development that incorporated presentations on integrating mathematics into their specific subject areas.
- Had more consistent professional development opportunities that provide examples integrating mathematics into their subject areas.
- Most teachers interviewed said they had not experienced enough opportunities to engage in professional development involving integrating mathematics across the curriculum to influence their persistence with integrating mathematics into their lesson activities.
- Could collaborate or team teach with a mathematics teacher to help overcome problems they may encounter with integrating mathematics into their instruction

Mintzes et al. (2013) asserted that teachers who participate in STEM focused professional learning teams increase their knowledge of mathematics and science and learn more important strategies for developing instructional activities that incorporate those disciplines.

Theme: Background Experiences

This theme is based on the following codes: Experiences with Learning Mathematics, Experiences with Teaching Mathematics.

Experiences with Learning Mathematics. Of the non-STEM teacher interviewed, fewer than half (42%) had negative experience with learning mathematics. A quarter of them (25%) had positive experiences with learning mathematics and one third (33%) of them had mixture of positive and negative experiences with learning mathematics. Causes of the negative experiences seem to be poor instruction, or poor rapport with the instructor. Also, some of the teacher interviewees said they were just indifferent about learning mathematics or never really liked mathematics as a subject area. Some of the non-STEM teacher interviewees now wish they had adopted a better attitude towards learning mathematics because they are now faced with encouraging their own children to be diligent about learning mathematics.

Experiences with Teaching Mathematics. Surprisingly, two of the teacher interviewees had prior experiences with teaching mathematics before being employed at the local STEM school. These experiences seem to positively contribute to their confidence and competence for integrating mathematics into their lesson activities. These experiences also seem to generate open-mindedness about the value and importance learning mathematics.

Pajares (1995) asserted people are more likely to engage in tasks about which they feel competent and confident. However, Bandura (1977) asserted people encounter varying forms of efficacy-altering experiences that do not affect everyone equally. When given appropriate skills and resources, a person's self-efficacy increases for handling challenging situations (Bandura, 1977, 1994).

Theme: Professional Development

This theme is based on the following codes: Resources, Course-Specific Mathematics Integration, Basic Mathematics Skills Review, and Consistent Professional Development.

Resources. Non-STEM teacher interviewees said they would like opportunities to create lesson activities involving mathematics integration across the curriculum. They would like access to hands on activities involving mathematics applications and use of technology applications involving mathematics applications, including interactive internet resources.

Course-Specific Mathematics Integration. Non-STEM teacher interviewees said they would like to see professional development presentations that demonstrate how mathematics may be integrated in to their specific subject areas.

Basic Mathematics Skills Review. Some of the non-STEM teacher interviewees said they would like to engage in a review of basic mathematics concepts so that their memories can be refreshed about the use of those concepts, skills and formulas. This will enable them to correctly use them in their instruction that involves mathematics integration.

Consistent Professional Development. Based on the local non-STEM teachers' interview responses, they would like to have more consistent opportunities to engage in professional development sessions that target mathematics integration across the curriculum. They would also like more information about state test preparation that specifically relates to their individual subject areas.

Nadelson (2013) asserted professional development and support is essential to prepare and qualify teachers to facilitate STEM instruction. When teachers are provided with strategies and resources related to integrating STEM content across the curriculum and across grade levels, it increases their efficacy and comfort for teaching STEM content. According to Rinke et al. (2016), professional development helps teachers develop increase comfort and confidence with facilitating STEM instruction across the curriculum. Teacher participation in professional development gives teachers access to new instructional strategies and use of curriculum materials (Kennedy & Smith, 2014). Improvement in teacher efficacy is directly related to improvement in student progress (DeChenne et al., 2015; Kennedy & Smith, 2014).

Theme: Collaboration

This theme is based on the following codes: Lesson Planning, Course Content Connections to Mathematics, Technology Use, and STEM Projects.

Lesson Planning. Non-STEM teacher interviewees said they would like opportunities to collaborate with a mathematics teacher to plan lesson that incorporate mathematics applications. The mathematics teacher could review the non-STEM course content to identify areas most suited for mathematics applications. Also, the non-STEM teacher can review the mathematics course content and identify opportunities for incorporating non-STEM course content into a mathematics lesson. These collaborations could create strong learning connections for students.

Technology Use. Non-STEM teacher interviewees would like more access to up-to-date technology that provides applications for supporting mathematics integration into their subject areas.

STEM Projects. Three of the teacher interviewees mentioned they are open to collaborating with mathematics teachers to support students with developing and completing STEM projects. Completion of a STEM project is a graduation requirement for the local STEM school's seniors.

Bandura (1994) identified four sources of self-efficacy, one of which is social persuasion. When teachers collaborate to facilitate STEM instruction, they can offer each other verbal encouragement and social support, as they work together to help students connect concepts and skills across the curriculum (Bandura, 1994; Kennedy & Smith, 2014). Collective efficacy, a form of teacher efficacy identified by Zambo and Zambo (2008), involves teachers' collaboration with an educational environment. Components of collective efficacy include group competence and contextual influence. As teachers work collaboratively to plan and implement interdisciplinary lessons incorporating mathematics applications, their levels of competence are strengthened to produce quality desired learner outcomes. According to Vangrieken et al. (2015), teacher collaboration creates increased teacher motivation and self-efficacy for teaching a content area.

Theme: Team Teaching

This theme is based on the following codes: Same Classroom Setting, Different Classroom Settings. Teacher interviewees welcome team teaching with mathematics teachers because it would increase their confidence and competence for integrating mathematics into their instruction.

Same Classroom Setting. Teacher interviewees indicated the mathematics teacher or consultant could take the lead for teaching the part of the lesson involving mathematics applications or the mathematics teacher could assist students individually with completing the lesson assignments.

Different Classroom Settings. Some teacher interviewees indicated after planning an interdisciplinary unit with the mathematics teacher, each teacher could teach the lessons applicable to their individual subject areas within their own classroom, but place emphasis on the connections between the non-STEM subject area and the mathematics subject area.

Improvement in teacher efficacy occurs when teachers have social support from colleagues (Kennedy & Smith, 2014). Collaborative social support lead to better academic planning, goal setting and diversity in planning lesson activities (Vangrieken et al., 2015). Integrative approaches to teaching STEM content areas foster increased interest in mathematics and improves students' attitudes about mathematics learning at its real-world applications (Kertel & Gurel, 2016).

The data generated from the interview responses were used to inform the study's research questions. The following table displays the relationship of the themes and codes to the research questions and examples of study participants' perspectives.

Table 2

Research Questions, Related Themes and Codes, Participants' Perspectives

Research Question	Themes (Related Codes)	Sample Perspectives
RQ 1: What are the local school's non-STEM teachers' perceptions of their competence and confidence with respect to integrating mathematics into their instruction?	Teacher Efficacy (Confidence, Competence)	I need to see course specific activities for integrating mathematics into my subject area.
	Background Experiences (Learning, Teaching)	Never really liked math a lot. The better the math teacher, the more confidence I had in doing math and the harder I tried. I try hard to be one of those teachers who motivates students to try a little harder in math
	Collaboration (Lesson Planning)	Collaborating with a math teacher would be very helpful and it would help me determine opportunities for integrating math into my instruction.
	Team Teaching (Same Classroom, Different Classrooms)	Team teaching with a math teacher would help me learn the math skills and concepts.
	Professional Development (Course Specific Examples of Math Integration)	I need course specific examples of how to integrate math with my subject area. I would like to learn more strategies to integrate math

		into my instruction.
RQ 2: What factors influence the local school's non-STEM teachers' self-efficacy for integrating mathematics into their instruction?	Background Experiences (Learning, Teaching)	I was indifferent to learning math. I was a "when am I ever going to use this" type student. Now I try to teach my daughter to have the opposite attitude.
	Collaboration (Lesson Planning)	I am not afraid to teach math. Just need to know what I am doing beforehand. Two minds can piggy back off each other.
	Team Teaching (Same Classroom)	The math teacher could take the lead with teaching the math concepts and skills.
	Professional Development (Resources)	I am able to learn new things about the math concepts and new approaches to solving problems. Then I can use the language to connect the math to English and break the problems down to my students.
RQ 3: How do the local school's non-STEM teachers value mathematics as a subject area needed in real life? Do these value beliefs influence their motivation for integrating mathematics into their instruction?	Teacher Efficacy (Motivation)	Crucial. It allows for analytical and critical thinking. I just wish I could do more with it, so I could help the students who struggle with it. Math is much more than numbers. Leaning it leads to solving more complex problems in the future, especially in college and careers.

	Collaboration (Course Content Connection)	It is very valuable and needed all the time. Collaborating with a math teacher would increase my motivation. I wouldn't want to team teach all day or every day, but as long as the math applications fit into my course content, I would not mind the collaboration.
	Professional Development (Course-Specific Mathematics Integration)	Professional development activities need to be more course-specific; maybe have a teacher from my subject area show how math can be integrated into a lesson. Professional development activities on math integration are usually too general.
RQ 4: How does working in a STEM environment affect the local school's non-STEM teachers' perseverance and persistence with integrating mathematics into their instruction?	Teacher Efficacy (Perseverance, Persistence)	The math application has to fit into my course content.
	Collaboration (Course Content Connection)	Need help identifying opportunities to integrate math.
	Team Teaching (Same Classroom, Different Classrooms)	I could consult my team teacher about how to relate the math skills to my lesson.
	Professional Development (Course-Specific Mathematics Integration	Need examples of course-specific math integration.

Discussion

Self-efficacy is the conceptual framework underpinning this study. The purpose of the study was to explore non-STEM teachers' self-efficacy for integrating mathematics across the STEM charter high school's curriculum. A review of the data collected has generated the following responses to the study's research questions.

RQ 1: What are the local school's non-STEM teachers' perceptions of their competence and confidence with respect to integrating mathematics into their instruction?

Data analysis results reveal that non-STEM teachers' confidence and competence for integrating mathematics into their instruction will increase when they:

- have increased opportunities to collaborate or team teach with mathematics teachers
- have opportunities to observe mathematics teachers' instruction
- have increased opportunities to engage in professional development related to integrating mathematics across the curriculum, especially when the mathematics integration is course-specific.

Bandura (1994) identified four sources of self-efficacy: mastery experiences, vicarious experiences (modeling influences), social persuasion and emotional and physical states of being. Background experiences with learning mathematics and in some cases teaching mathematics may have some influence on the amount of confidence and competence non-

STEM teachers would have for integrating mathematics into their current instruction. Non-STEM teacher interviewees said they felt any negative experiences with learning mathematics can be overcome with the support of collaborating with a mathematics teacher and/or consultant.

RQ 2: What factors influence the local school's non-STEM teachers' self-efficacy for integrating mathematics into their instruction?

Factors that influence the local school's non-STEM teachers' self-efficacy for integrating mathematics into their instruction include:

- Background experiences with learning and teaching mathematics.
- Opportunities to collaborate or team teach with a mathematics teacher.
- Multiple opportunities to engage in professional development involving integrating mathematics into their specific subject area.
- Use of technology resources that provide information about and practice with mathematics concepts and skills.
- Access to hands on activities that include mathematics applications.

According to Zambo and Zambo (2008), there are two forms of teacher efficacy: individual efficacy and collective efficacy. The components of individual efficacy, personal competence and personal level of influence, affect the proficiency level at which a teacher can influence student learner outcomes. The components of collective efficacy, group competence and contextual influence affect a teacher's belief about working proficiently with colleagues to provide desired learner outcomes.

RQ 3: How do the local school's non-STEM teachers value mathematics as a subject area that is needed in real-life? Do these value beliefs influence their motivation for integrating mathematics into their instruction?

All of the teachers interviewed value mathematics as subject area needed in real life to the extent of knowing how to apply the mathematics life skills such as, money management or making informed consumer decisions. But only a few of the teachers interviewed recognize the importance of learning mathematics in relation to future college and career goals. Their value beliefs about mathematics minimally increase their motivation for integrating mathematics into their instruction. Pajares (1995) asserted that people are more motivated to engage in tasks when they value the outcomes and anticipate successful outcomes.

RQ 4: How does working in a STEM educational environment affect the local school's non-STEM teachers' perseverance and persistence with integrating mathematics into their instruction?

Interview responses from the local school's non-STEM teachers indicated that working in a STEM educational environment does not necessarily influence their perseverance and persistence with integrating mathematics into their instruction, because more communication is needed between non-STEM teachers and STEM teachers about course content. Collaborating or team teaching with a mathematics teacher, requesting assistance from a mathematics consultant, engaging in professional development that involves integrating mathematics across the curriculum, are the factors that influence non-STEM teachers' perseverance and persistence with integrating mathematics into their instruction. According to Seals et al. (2017) and Milner and Hoy (2003), teachers who have high levels of self-efficacy demonstrate more perseverance and persistence in helping students succeed and have and increased commitment to teaching. Teachers may need to collaborate with colleagues to obtain full understanding of unfamiliar concepts (Vamgrieken et al., 2015).

Validating the Findings

The findings of this study have been validated with the use of member checks, a peer reviewer, and an external auditor. Each of these sources confirmed the accuracy of the researcher's interpretation of the data. Member checking was conducted by allowing participants to review and critique the developed themes for accuracy and to validate that the study findings correctly represent their perspectives. Participants confirmed the accuracy of their own data. Based on the interview responses, a preliminary data analysis update document was prepared that included themes and codes which were developed to organize and categorize the data. It also included preliminary responses to the study's research questions. The peer reviewer and external auditor had access to copies of the study, the interview recordings and transcripts, and the data analysis update document. After careful review of these documents, the peer reviewer and external auditor concurred that the data were accurately represented and reported in the data analysis update document.

Summary of Findings

The problem in this study involves a STEM charter high school's requirement that non-STEM teachers integrate mathematics into their instructional activities. The goal of this study was to explore non-STEM teachers' self-efficacy for integrating mathematics across the STEM charter high school's curriculum. The interview questions and the research questions related to the study are aligned to the conceptual framework of self-efficacy.

Study participants' interview responses have generated valuable data about the local school's non-STEM teachers' perspectives about integrating mathematics across the curriculum. Based on the data analysis, the local school's non-STEM teachers need more opportunities to engage in collaboration and/or team teaching with mathematics teachers for the purpose of facilitating quality lesson activities involving integration of mathematics across the curriculum. These non-STEM teachers are also need consistent and comprehensive professional development that provides course-specific examples of how to integrate mathematics into the course content and instruction of their individual subject areas. Most of the non-STEM teachers' background experiences with learning mathematics do not negatively influence their confidence and competence for integrating mathematics into their instructional activities. Two of the teacher interviewees have had some experiences with teaching mathematics prior to becoming a part of the STEM charter high school's faculty. However, it should be noted that mathematics is not their major field of study. Their background experiences with teaching mathematics seemed to make them be more open-minded about the value of mathematics as a subject area needed in real life.

Bandura (1977) defined efficacy expectations as "a person's estimate that a given behavior will lead to certain outcomes" (p.123) and will determine the coping behavior and extent of effort people will exercise when confronted with adverse situations. Non-STEM teachers who participated in the study indicated their confidence and competence for integrating mathematics into their instructional activities would increase when given opportunities to observe a mathematics teacher's instruction, and to collaborate or team teach with mathematics teachers. Confidence and competence are constructs of self-efficacy. Self-efficacy beliefs determine a person's feelings and perceptions of self-motivation to engage in certain tasks (Bandura, 1977, 1994). Bandura (1993) asserted a teacher's self-efficacy belies can predict a student's sense of mathematical achievement during an academic year. Teachers with high levels of self-efficacy demonstrate more perseverance and persistence toward helping students succeed (Milner & Hoy, 2003). Perseverance, persistence and motivation are also constructs of self-efficacy. Based on the study participants' interview responses, it is evident that their levels of self-efficacy would grow stronger with increased opportunities to collaborate or team teach with mathematics teachers. Bandura (1994) asserted that strengthening self-efficacy beliefs can be influenced by modeling experiences. The study participants indicated their need for examples of course-specific mathematics integration with their individual subject areas during professional development sessions.

It is evident by the data generated from the interviews that the local school's non-STEM teachers need support to strengthen their levels of self-efficacy integrating mathematics across the curriculum. It is evident that the project deliverable should be one that includes professional development that targets training and curriculum materials that contain instructional approaches and resources for integrating mathematics across the curriculum. Section 3 of this study contains a description of the professional development project designed to assist non-STEM teachers with increasing their levels of self-efficacy for integrating mathematics into their content areas. A literature review that supports the project is presented, as well as an evaluation plan for determining how the project goals will be met.

Section 3: The Project

Introduction

The goal of this study was to explore non-STEM teachers' self-efficacy for integrating mathematics across the STEM charter high school's curriculum. To achieve this goal, a qualitative research design was selected for this study. Data were collected via in-depth interviews using questions designed to capture participants' perspectives about the components of self-efficacy (confidence, competence, motivation, perseverance and persistence) in relation to integrating mathematics into their instructional activities. Participants' interview responses not only revealed their perspectives about integrating mathematics into their instruction, but also their value beliefs about the importance of mathematics as subject area needed in real-life. During the interviews, participants also shared information about what strategies and resources they felt they needed to effectively integrate mathematics into their disciplines.

Data analysis results were validated with the use of member checks, a peer reviewer and an external auditor. After sharing and discussing the results with my doctoral chair, the project genre of Professional Development/ Training Curriculum and Materials was selected as being the most appropriate genre for addressing the study problem and meeting the needs expressed by the study participants.

Description of Project Goals

Project goals for this study were based on the participants' interview responses. These goals were shared and discussed with my doctoral chair, secondary mathematics consultants and technology specialists, as well as current classroom teachers to ensure that the most current curriculum standards and up-to-date technology were included. All project modules include interactive activities and appropriate technology.

The major project goals include: identifying connections between non-STEM and STEM course content areas, providing activities designed to increase non-STEM teachers' levels of efficacy for integrating mathematics into their instruction, providing strategies and resources for integrating mathematics into non-STEM content areas, and providing strategies for collaboration and team teaching between non-STEM and STEM teachers.

Project Modules

I. The STEM Educational Environment

1. Characteristics of an Effective STEM Educational Environment
2. Course Content Connections between STEM and Non-STEM Courses
3. Interactive Activities That Promote Literacy and Numeracy Across The Curriculum
4. Mini Lessons Incorporating Literacy and Numeracy Strategies

II. Mathematics – A Valuable Tool

1. Why Do We Need Mathematics?
2. Problem Solving Techniques
3. Strategies for Integrating Mathematics Across the Curriculum

4. Mini Lessons Incorporating Problem Solving Techniques, Literacy and Numeracy Strategies

III. Teacher Collaboration and Team Teaching

1. Strategies for Collaboration and Team Teaching
2. Collaboration Between Mathematics Teachers and Non-STEM Teachers to plan interdisciplinary mini lessons that integrate mathematics with another content area, and have a real world connection
3. Team teaching to present mini lessons

IV. Interdisciplinary Lesson Planning

1. Review standards documents to identify topics that connect to mathematics
2. Interdisciplinary Lesson Planning
3. Identify appropriate technology Tools for use with lessons
4. Sample Lesson Presentations

Module 1 will set the stage for promoting interdisciplinary teaching and learning as an effective tool for helping students make connections between the content areas and apply their learning across the curriculum. This module will provide practice activities with the reading and writing standards that are applicable to integrating mathematics across the curriculum. Teachers will have opportunities to collaborate on the planning and implementation of these activities in their classrooms.

Module 2 will provide an overview of the value of learning mathematics, its influence on learning in other content areas and its impact on preparation for future college and career choices. It will give teachers opportunities to engage in mathematics problem solving techniques and acquire and practice strategies for integrating mathematics across the curriculum. Non-STEM teachers will have opportunities to increase their competence and confidence for integrating mathematics into their lesson activities by collaborating with mathematics teachers and consultants to plan lessons involving integration of mathematics into their specific content areas.

Module 3 will involve practice with focused collaboration and communication between mathematics teachers and teachers of other content areas. Teachers will have opportunities to practice focused procedures for collaborative planning, team teaching, and sharing instructional practices.

Module 4 will involve ways to access strategies and resources for integrating mathematics across the curriculum. Teachers will work in teams to plan and present interdisciplinary lessons that incorporate mathematics applications. Each team will have at least one mathematics teacher and/or consultant. Technology tools such as laptops, graphing calculators, and Smart Boards will be available.

Rationale

Based on the data analysis results for this study the project genre of Project Development/Training Curriculum and Materials is the most appropriate one for addressing non-STEM teachers' needs in relation to integrating mathematics across the

STEM charter high school's curriculum. Study participants' responses indicated a need for increased teacher efficacy for integrating mathematics into their lesson activities. This was evidenced by their responses to interview questions involving confidence, competence, motivation, perseverance and persistence for integrating mathematics into their lesson activities. Study participants also indicated a need for consistent professional development that includes course-specific examples of mathematics integration into their disciplines as well as strategies and resources for integrating mathematics across the curriculum. Opportunities to observe mathematics teachers' instructional practices, collaborate and team teach with mathematics teachers was also indicated as important needs to facilitate integration of mathematics into their instruction. The project modules have been designed to address each of these expressed needs.

The other project genres are not applicable to the purpose of this study, which is to explore non-STEM teachers' self-efficacy for integrating mathematics across the local school's curriculum. The Evaluation Report genre is not applicable because the purpose of this study does not involve the evaluation of an educational program or curriculum standards. The Curriculum Plan genre is not applicable to this study because the purpose of this study does not involve development of a new curriculum. The genre of Policy Recommendation with Detail is not applicable to this study because changing the local school's academic policies is not a part of the purpose for this study.

Review of Literature

A comprehensive professional development program involving mathematics integration is most appropriate for addressing the expressed needs of the local school's non-STEM teachers in relation to integrating mathematics into their lesson activities. The professional development project for this study has been designed based on the data analysis results. Project modules will contain interactive activities that will inform solutions to the problem in this study.

Professional Development and Teacher Efficacy

The problem in this study involves non-STEM teachers' self-efficacy for integrating mathematics into their instruction. The conceptual framework underpinning this study is self-efficacy theory. Nurlu (2015) defined self-efficacy as a person's "I can or I can't" belief which can have a definite effect on their motivation for success or failure. Teacher-efficacy can be defined as a teacher's belief in their ability to positively influence student learning (Carney, Brendefur, Thiede, Hughes & Sutton, 2016). According to Carney et al. (2016), teachers' beliefs influence their decisions about implementing new and unfamiliar instructional approaches that can increase student achievement. Teacher efficacy is an important component of teacher effectiveness that can be linked to teacher behaviors and student outcomes (Bray-Clark & Bates, 2003). According to Bray-Clark and Bates (2003), self-efficacy involves task-specific beliefs that govern the choices, effort, and persistence with which teachers solve problems and face challenges. Teachers with high levels of self-efficacy demonstrate more effort and persistence with helping students succeed and build positive professional relationships with students that lead to increased student achievement (Bray-Clark & Bates, 2003; Nurlu, 2015). Althauser (2015) defined teacher efficacy in relation to mathematics teaching and learning. According to Althauser (2015), teacher efficacy can be divided into two constructs: general efficacy which is defined as a reflection of teachers' beliefs about general factors associated with how students learn mathematics and personal efficacy which is defined as an individual teacher's perception of his or her effectiveness to teach mathematics. Nurlu (2015) asserted that teachers with high levels of self-efficacy will work towards improving students' attitudes about learning mathematics and may assist students with overcoming their mathematics anxiety. Consistent professional development involving mathematics teaching and learning may lead to improved student achievement in mathematics (Althauser, 2015).

Professional development has a positive influence on teacher efficacy (Yoo, 2016). Professional development should be designed to positively influence teachers' self-efficacy for implementing instructional approaches that can improve student achievement (Carney et al., 2016; Corkin, 2015). Professional development experiences related to teacher efficacy can lay the foundation for continuous improvements in teacher effectiveness and student outcomes. Teachers with high levels of efficacy are more persistent about assisting students with overcoming difficulties. They will engage in more effective planning and implementation of lesson activities that will address students' needs (Bray-Clark & Bates, 2003). Teachers' self-efficacy influence the type of instructional strategies they will adopt and their instructional effectiveness (Corkin, 2015). High-quality professional development experiences are those which enable teachers to gain strategies and resources for enabling students to acquire and apply their knowledge and skills across subject areas (Althauser, 2015). High quality professional development experiences are a major concern for local school districts, states and the nation in relation to improving educational practices (Althauser, 2015; Bray-Clark & Bates, 2003).

Guiding Principles and Goals for Professional Development

STEM education is currently a priority on all levels of K-12 education (Avery & Reeve, 2013; Chiyaka, Kibirige, Sithole, McCarthy & Mupinga, 2017). School administrators rely on professional development as a key strategy for improving teachers' pedagogical and content knowledge and skills (Chiyaka et al., 2017). Professional development offers opportunities for STEM educators to learn strategies for implementing and integrating new and effective instructional approaches into their classroom environments (Avery & Reeve, 2013). STEM professional development should provide an environment that is organized, supportive of teachers' personal and professional needs, values and input (Avery & Reeve, 2013; Matteson, Zientek, & Ozel, 2013). Teacher professional development positively affects teaching practices and student outcomes (Capraro, R., Capraro, M., Scheurich, Jones, Morgan, Huggins, Corlu, Younes & Han, 2016). Since teachers have a direct influence over student learning, it is important to invest in resources that can assist teachers in developing and implementing quality learning experiences for students (Avery & Reeve, 2013).

Professional development should be aligned with curriculum and subject matter, linked to classroom activities and sustained over time to enable increase effectiveness in teaching practices (Capraro, et al., 2016; Chiyaka, et al., 2017; Desimone & Pak, 2017; Matteson, Zientek, & Ozel, 2013). Sustained professional development supports STEM reform (Capraro, et al., 2016). Professional development is most effective when: it does not entail major disruptions or extra work requirements for teachers; implemented changes are developed slowly and evidence is provided that these changes effectively work in the classroom; sufficient time is provided for such changes to be implemented (Matteson, Zientek, & Ozel, 2013). Mathematics teachers who participated in a Total Quality Grant training program identified five main targets for teacher professional development. Those targets included resources for diverse student populations, instructional resources, pedagogical uses of technology, additional time for exploring technology applications and peer sharing. These teachers wanted instructional strategies and resources designed specifically to meet the needs of the students they were teaching (Matteson, Zientek, & Ozel, 2013). Instructional technologies related to mathematics can improve student achievement and attitudes and motivation towards learning mathematics, especially those technology applications that incorporate immediate feedback features (Matteson, Zientek, & Ozel, 2013).

When teachers become comfortable with technology, instructional strategies and curriculum, they are more responsive to student needs (Matteson, Zientek, & Ozel, 2013; Bratt, Sundheim, Pound & Rogers, 2017). Professional development helps in-service teachers keep abreast of changes and advances in teaching technology, academic standards, subject content and classroom management techniques (Chiyaka et al., 2017; Bratt et al., 2017).

Professional development outcomes should include positive teaching attitudes towards adopting and implementing new educational practices, application of increase academic knowledge and skills resulting in increased student achievement (Chiyaka et al., 2017). According to Chiyaka et al. (2017), professional development experiences should target classroom-based learning, collaborative learning, peer-mentoring and coaching. Desimone and Pak (2016) identified five key features of professional development: content focus, active learning, coherence, sustained duration and collective participation. Content focused activities include subject matter content and how students learn that content. Active learning involves opportunities for teachers to engage in interactive presentations, analyzation of student work related to content presented and lesson observations, rather than passive listening to lectures (Desimone and Pak, 2016). Coherence refers to inclusion of professional development sessions that are aligned with school curriculum goals, district and state academic standards. Sustained duration involves consistent opportunities throughout the school year for teachers to collaborate and assess the effectiveness of implementing strategies and lesson approaches presented in professional development sessions. Collective participation involves opportunities for groups of teachers from the same grade, subject area, or school to share best practices related to classroom teaching and learning, and the building of productive learning communities (Desimone and Pak, 2016).

The goal of STEM professional development is to prepare teachers to motivate and prepare students for STEM college and career paths. In order to encourage students to pursue STEM fields, teachers need to be aware of workplace requirements (Avery & Reeve, 2013). Educators recognize the need for reform in STEM education to better prepare students for STEM careers. There are disconnections between STEM classroom learning and the workplace competencies needed to sustain a successful STEM career (Jang, 2016). Important 21st century job market skills include: adaptability, complex communication skills, non-routine problem solving skills, self-management, as well as, cognitive and social skills (Cinar, Pirasa & Sadoglu, 2016; Jang, 2016). Class activities should encompass integrated interdisciplinary sets of complex problems that can be solved using collaboration, critical thinking and STEM knowledge (Jang, 2016).

Integrating Mathematics into Other Content Areas

Common Core State Standards advocate an increase in students reading, writing and mathematics skills, to prepare students to achieve college and career goals (Billingsley, 2013). Literacy should be emphasized in all content areas to enable students to learn effectively by thinking critically as they process and produce information (Ming, 2012). According to Ming (2012), content area literacy is defined as the ability to use listening, speaking, reading, writing and visualization to access information within specific disciplines. The frequent use of reading and writing activities enables students to make connections between course content and the real world. Mathematics authentic writing includes explanations of solutions and procedures, descriptions of concepts and figures, drawings, diagrams and pictures that connect parts of problems (Ming, 2012). There is growing pressure to increase these skills across the curriculum by using integrative approaches to learning experiences. Content area literacy strategies strengthen students' language arts skills and assist students with becoming critical thinkers and problem solvers (Ming, 2012). According to Ming (2012) use of content area literacy strategies can help students make meaning from content area language and write explanations in their own words to explain problem solutions. Harkness and Brass (2017) suggests seven content area literacy strategies that can be used in instruction on the secondary level. These strategies include: read-alouds, KWL charts, graphic organizers, vocabulary construction, writing to learn, structured notetaking and reciprocal teaching. Use of these strategies can cause improved student achievement and assist students with making connections between content areas.

Integration is currently found on all levels of education, including the graduate level (Billingsley, 2013; Dow, 2014; Ming, 2012). According to Dow (2014), there is growing pressure to create a STEM literate society, a 21st century workforce equipped with competencies in science, technology, engineering and mathematics, and a plan for advanced research and development of innovations that can address the nation's social problems.

Student success in the workplace is dependent on the ability to build relationships by collaboratively solving problems and sharing information, and the ability to design and create innovative solutions to societal problems (Quigley & Herro, 2016). Classroom instructional practices should target 21st century skills along with applications of content knowledge. Students need to apply content knowledge in relevant contexts in order to transfer knowledge and skills to real-life situations (Wilder, Lang & Monegan, 2015). Professional development training enables teachers to acquire the necessary pedagogical and content knowledge to implement interdisciplinary lesson activities that are aligned to the Common Core Standards. Solving real world problems involves multidisciplinary tasks (Smilan, 2016). Interdisciplinary lessons increase students' motivation to learn and create more meaningful learning by allowing students to make personal connection between subject areas (Billingsley, 2013).

In response to the U.S. quest for strengthening its economy and global competitiveness, increased emphasis has been placed on STEM in multiple education settings (Brelias, 2015; Fitzallen, 2015). U.S. schools are under pressure to get students to learn more mathematics. Mathematical literacy is an essential component needed by citizens to understand, influence and make informed decisions about political, social and economic situations (Brelias, 2015). Mathematics supports the other STEM core disciplines because it serves as the language of science, engineering and technology, and it enables increase conceptual understanding of those disciplines (Fitzallen, 2015). Mathematics teachers are in search of real-life Mathematics, science, English language arts and the arts and humanities are usually taught in isolation with very little emphasis on connections between the subject areas. There is an absence of meaningful context. Integrated projects need to be developed across multiple disciplines (Wilder, Lang & Monegan, 2015). Teaching mathematics in isolation negatively impacts student engagement and motivation, causing low mathematics proficiency (Wilder, Lang & Monegan, 2015).

Rigorous interdisciplinary instruction that links visual arts, literacy, mathematics skills and cognitive skill development can increase students' mathematical literacy skills while nurturing their creative art skills (Cunnington, Kantrowitz, Harnett, & Hill-Ries, 2014). Visual literacy and the ability to think creatively are critical skills related to 21st century communication processes (Smilan, 2016). In an interdisciplinary collaborative environment integrating the arts with mathematics can make mathematics less threating, while maintaining its rigor (Wynn & Harris, 2013).

STEM is now evolving into STEAM (integration of science, technology, engineering and mathematics with the arts). The arts are becoming an integral part of a curriculum that can drive students to excel in STEM (Wynn & Harris, 2013). Wynn and Harris (2013) posit when science and mathematics become strictly quantitative, there is a disconnect between mathematics and real world applications. Skills and techniques used in mathematics, science and English language arts connect to studio inquiry and museumbased analysis (Smilan, 2016). Teachers are encouraged to help students make connections between the arts and mathematics (Jones & Pearson, 2013).

Mathematics applications can also be used to address social justice issues. The language of mathematics can be used to describe and construct social phenomena by examining their assumptions, processes and effects (Brelias, 2015). The opinions we formulate about people may depend on the statistics we access about them. These statistics often need validation, because such information can be used to create societal myths (Brelias, 2015). For example, mathematical inquiries about social inequality can reveal evidence to support arguments that some problems may be due to inequitable social arrangements rather than individual failure (Brelias, 2015).

Teaching mathematics applications can be a valuable tool that leads to changes in students' perceptions about the importance of learning mathematics (Brelias, 2015). Knowledge integration supports the importance of incorporating collaboration, communication and real world experiences in the design of lesson activities (Krug & Shaw, 2016). Organizations and educational institutions nationwide are engaged in developing workshops, conferences, and professional development to assist teachers with planning and implementing STEAM approaches into classroom instruction (Wynn & Harris, 2013).

Professional Development and Teacher Collaboration

Wenger and Wenger-Trayner (2015) defined communities of practice as groups of people who interact on a regular basis to share a common concern or passion for something they do and want to learn how to do better. Members of these communities are committed to achieving a goal and engaging in joint activities and discussions related to their vision and goals. These members are connected to a common profession and share experiences which enable them to learn from each other ways of addressing and solving recurring problems related to their professional practice (Wenger and Wenger-Trayner, 2015). PLCs are communities of practice characterized by: shared beliefs, visions and goals; consistent, focused, organized meeting sessions that include discussions about content and pedagogical knowledge; inclusion of time for reflection on how to improve current teaching practices, and planning and implementation of new and unfamiliar instructional practices for the purpose of improving student achievement (Andrews-Larson, Wilson & Larbi-Cherif, 2017; Battersby and Verdi, 2015; Bowe & Gore, 2017; Kuh, 2016; Lewis & Perry, 2014; Lofthouse & Thomas, 2017; Murray, 2015; Witterholt, Goedhart & Suhhre, 2016).

Professional development must be linked to PLCs that are consistently active, foster innovative teaching practices, and are committed to improving student achievement (Stewart, 2014). PLCs have been established in multiple school districts to sustain teacher collaboration (Battersby &Verdi, 2015). Teacher collaboration involves teachers working together towards a common goal by collectively sharing ideas and knowledge to design and develop new approaches to teaching and learning, which can result in improved student achievement (Lofthouse & Thomas, 2017). Collaboration provides opportunities for teachers to examine, critique and support each other's work in a non-threatening environment (Murray, 2015). Murray (2015) also posits that teacher collaboration provides opportunities for teachers to do interdisciplinary lesson planning, review and interpret student work, and write common assessments. Such opportunities may lead to implementation of more effective instructional strategies and practices. Collaboration supports professional development when schools advocate PLCs that incorporate peer observations coaching, and mentoring (Ostovar-Nameghi & Sheikhahmadi, 2016). Guiding principles for a group learning environment include: establishing an atmosphere of trust and respect, valuing teacher participants' input by allowing them to choose topics for professional learning sessions, scheduling time for reflection and feedback on implemented teaching and learning strategies (Stewart, 2014).

PLCs are models of teacher collaboration that vary in name and format. Examples of such models include Collaborative Reflective Teaching Cycles (CRTC), Critical Friends Groups (CFG), Quality Teaching Rounds, and Lesson Study groups. Collaborative Reflective Teaching Cycles is a model of profession learning that involves three phases: planning, teaching, and reflecting. During the planning phase, teachers decide what to teach in relation to core objectives, students' prior knowledge and instructional approaches that will lead to the most successful student outcomes. The teaching phase involves implementation of the plan and making changes in pedagogy if needed, while continuously assessing student learning. During the reflection phase, the depth to which students have grasped the lesson concepts in considered by recalling classroom experiences and reviewing student work (Murray, 2015). Critical Friends

Groups focus on improvement of practice and student learning using a structured protocol for teacher collaborations (Kuh, 2016). Critical Friends Group sessions involve team building activities, observations and feedback sessions related to classroom instructional practices, review of student work, and discussions about improving instructional practices and student learning (Kuh, 2016). Quality Teaching Rounds focus on pedagogy to guide teachers' efforts towards improvement of their practices (Bowe & Gore, 2017). A teaching round involves school leaders, teachers and/or student teachers in groups of four to eight participants. A round consists of three sessions: during the first session, participants engage in a discussion about a professional reading, that is selected by one of the participants, for the purpose of establishing a shared basis for a professional conversation that may reveal participants' values and beliefs in relation to teaching and learning; the second session involves a classroom observation during which one of the participants teaches a lesson and is observed by the other participants, in order to provide a forum for sharing teaching and learning practices; the third session involves all participants in an evaluation of the lesson using the Quality Teaching Framework. This framework provides specific guidelines for good teaching practices such as questioning that elicits higher order thinking skills, lesson activities that show high expectations for student outcomes, and knowledge integration (Bowe & Gore, 2017). Lesson Study is a common form of professional learning that originated in Japan. Teachers conduct study-plan-do-reflect inquiry cycles (Lewis & Perry, 2013). Teachers study curriculum to consider long term teaching goals; plan and implement lessons based on those goals, and then reflect on the quality of teaching and learning based on student learning outcomes (Lewis and Perry, 2013).

PLCs are linked to the Professional Development Cycle of Continuous Improvement. According to Stewart (2014), the Professional Development Cycle of Continuous Improvement has five phases: identifying student learning needs, identifying related teacher learning needs, learn or review concepts, apply concepts to lessons, and critique and reflect lesson outcomes. Professional development should value local expertise and the collective wisdom of teachers as they collaborate to share and assess valuable teaching experiences and practices (Battersby & Verdi, 2015).

At the local STEM charter high school chosen for this study, teachers of non-STEM courses are required to integrate mathematics into their instructional activities. However, it is not known to what extent these teachers have the self-efficacy needed to integrate mathematics into their content areas. A qualitative research design was utilized for this study, during which data were collected via in-depth personal interviews. The non-STEM teachers, who agreed to participate in this study, indicated a need for strategies and resources that could assist them with integrating mathematics into their instructional activities. Their interview responses also indicated a need for increased collaboration with STEM teachers, especially mathematics teachers, for the purpose of reviewing non-STEM and STEM course content, to plan and implement interdisciplinary lessons that include mathematics applications.

The project genre of Professional Development/Training Curriculum and Materials is most appropriate for addressing the local problem and meeting the needs expressed the non-STEM teacher study participants. Self-efficacy theory underpins this study. Athauser (2015) defined teacher efficacy in relation to mathematics teaching and learning. According to Athauser (2015), teacher efficacy can be divided into two constructs: general efficacy (a reflection of teachers' beliefs about how students learn mathematics), and personal efficacy (an individual teacher's perception of his or her effectiveness to teach mathematics). Professional development can be designed to positively influence teachers' self-efficacy for implementing effective instructional approaches that will enable students to apply knowledge and skills across subject areas (Athauser, 2015; Corkin, 2015; Yoo, 2016). Consistent, high quality professional development experiences supported by active, focused PLCs can assist teachers with gaining increase self-efficacy, strategies and resources for integrating mathematics across the curriculum (Athauser, 2015; Avery & Reeve, 2013; Wenger & Wenger-Trayner, 2015).

For this study, interview questions were designed to inform the research questions and specifically to capture study participants' perspectives about their efficacy for integrating mathematics into their instructional activities. Twelve of the sixteen non-STEM teachers on staff at the local school agreed to participate in this study. Based on study participants' interview responses themes and codes were identified to organize and categorize the data. The following themes and (codes) were identified:

Teacher Efficacy (Codes: Confidence, Competence, Motivation, Perseverance, Persistence),

Background Experiences (Codes: Experiences With Learning Mathematics, Experiences With Teaching Mathematics),

Professional Development (Codes: Resources, Course-Specific Mathematics Integration, Basic Mathematics Skills Review, Consistent Professional Development),

Collaboration (Codes: Lesson Planning, Course Content Connections to Mathematics, Technology Use, STEM Projects),

Team Teaching (Codes: Same Classroom Setting, Different Classroom Settings).

Project goals and modules were developed based on the themes and codes identified to characterize the data. The content of the project modules is designed to address the expressed needs indicated by study participants during their interviews. The recurring needs expressed by most of the study participants included course-specific strategies, examples and resources for integrating mathematics into their individual subject areas, consistent professional development involving mathematics integration, increased communication with mathematics teachers, including time to observe, plan, and team teach with mathematics teachers and/or consultants.

The review of literature in this section of the study was conducted in relation to the chosen project genre of professional development, the study's conceptual framework of self-efficacy, and the study's data analysis results. Professional development that is designed to offer strategies and resources for implementing new and unfamiliar instructional approaches can positively influence teachers' self-efficacy (Carney, et al., 2016; Corkin, 2015;, Yoo, 2016). Corkin (2015) asserted that teachers' self-efficacy influences the type of instructional strategies they will adopt and their effectiveness with implementing those strategies. Guiding principles for quality professional development include well organized sessions that are supportive teachers' needs. Strategies and resources presented in professional development sessions should be aligned with curriculum standards and subject matter, and linked to class activities. Sessions should also include technology resources and applications, and interactive activities during which teachers can collaborate. Professional learning experiences should be sustained over time by giving teachers opportunities to reflect on implemented teaching strategies and approaches (Capraro, et al., 2016; Chiyaka, et al., 2017; Desimone & Pak, 2017; Matteson, Zientek & Ozel, 2013).

Since the study problem involves integrating mathematics across the curriculum, a part of the literature review involves the values of integrating mathematics into other content areas. Mathematics integration across the subject areas has become an important focus for linking mathematics applications to real world experiences (Billingsley, 2013; Smilan, 2016; Wilder, Lang & Monegan, 2015). Designing and implementing interdisciplinary lessons that include mathematics applications helps students apply their mathematics knowledge and skills across subject areas and connect their mathematics learning to the world outside the classroom (Billingsley, 2013). Designing quality interdisciplinary lessons requires teacher collaboration (Lofthouse & Thomas, 2017). Teacher collaboration supports the development of interdisciplinary lesson experiences for students, when teachers are given opportunities to share best practices, plan, implement and evaluate instructional approaches (Ostovar-Nameghi & Sheikhahmadi, 2016; Stewart, 2014). Quality teacher collaboration should be an extension of professional learning experiences that incorporated strategies and resources for developing and implementing classroom learning activities that can improve student achievement (Stewart, 2014).

The project for this study has been designed to address non-STEM teachers' efficacy for integrating mathematics across the curriculum. The project modules will include interactive activities that are designed to increase non-STEM teachers' competence and confidence with integrating mathematics into their instructional activities. Strategies, resources, and course-specific lessons examples for integrating mathematics across the curriculum will be included in the project modules. Multiple opportunities will be provided for non-STEM and STEM teachers to collaborate and design interdisciplinary lessons that can be utilized in their classrooms. Time for review and evaluation of implemented strategies and lesson approaches can be offered during the local school's weekly professional learning community sessions and/or during follow-up professional development sessions. Increased collaboration between non-STEM and STEM teachers may lead to teachers' increased motivation, persistence and perseverance for integrating mathematics across the curriculum.

Research for the review of literature in this section of the study was conducted in relation to the project genre of professional development, the conceptual framework of self-efficacy, and the study's data analysis results. Topics researched include professional development, mathematics integration, teacher collaboration, professional learning communities, the STEM educational environment, and mathematics education. Booleans researched in relation to these topics include: *professional development and (teacher efficacy, teacher collaboration, mathematics education, mathematics integration, professional learning communities, STEM education, team teaching); non-STEM teachers and the STEM educational environment; mathematics applications and mathematics teaching and learning; mathematics and STEM education; STEM education and teacher collaboration; teacher efficacy and STEM education.* I selected those articles that best addressed professional development in relation to mathematics integration across the curriculum and the expressed needs of the non-STEM teachers who participated in the study.

Project Description

Potential resources needed to support and implement the professional development that includes the presentation of this project include characteristics of a successful STEM educational environment, content area curriculum standards documents, and cross curricula literacy standards that will assist non-STEM teachers with integrating mathematics into their instructional activities. Interactive professional learning activities that focus on teacher collaboration for incorporating course specific examples of integrating mathematics applications into lesson activities must be developed and utilized in the professional development sessions. Support for sustained professional learning beyond these professional development sessions could be established during the local school's weekly PLC sessions. During this time teacher would have opportunities to collaborate about the interdisciplinary instructional approaches for integrating mathematics across the curriculum.

Potential barriers that might hinder the project deliverable would be: teacher attitudes and beliefs about the importance of integrating mathematics across the curriculum, time constraints in relation to implementing mathematics application lesson activities verses implementation of standardized testing skills activities, and administrative support for allowing ample professional development time for full development of the project. The following table displays the recommendations for solutions to these barriers.

Table 3

Project Barriers and Proposed Solutions

Recommendation	Potential Barrier	Solution to Barrier
Use of content area literacy strategies to promote connections between non-STEM and STEM subject areas	Teachers' attitudes and beliefs about importance of integrating mathematics across the curriculum to improve student achievement	Provide researched based evidence and training for the support and use of literacy strategies in all content areas as a tool for increasing student achievement
Use of PLC time to plan and reflect on interdisciplinary lesson activities that include mathematics applications	PLC time mainly focused on other tasks such as standardized test preparation	Plan and implement interdisciplinary lessons that include test-skill practice and strategies
Consistent professional learning time devoted to mathematics integration	Professional development for mathematics integration only offered once or twice a year	Allow time in each professional development and PLC session for training, discussion, and/or reflection on integrating mathematics across the curriculum

Implementation and Timetable

After obtaining approval for this project study, I will meet with the local school administrators and leadership team to present and discuss the data analysis results. Data analysis results will be presented via Power Point with time allowed for questions and concerns. If the proposed project is accepted, time will be requested for presentation of Modules 1 and 2 during the initial fall professional development time that occurs prior to the opening of school for students. Requested time for presentation of Modules 3 and 4 should be within the first 2 months after students return to school. After teachers have had time to plan and implement interdisciplinary lesson activities that incorporate mathematics applications, there should be focused time in PLC sessions for evaluation of implemented strategies and resources and their impact on student achievement. Teachers will have opportunities to revised procedures for improving their classroom practices in relation to integrating mathematics across the curriculum.

Roles and Responsibilities

In my role as researcher, I am required to present my study findings and the proposed project to the local school's administrators and leadership team. During this meeting I will discuss how the project was developed based on the study participants' interview responses and how the professional development project can assist non-STEM teachers with meeting the local school's requirement of integrating mathematics into their lesson activities. If the project is accepted by the local school's leadership, then I will present the proposed timetable for project implementation. I will accept the responsibility of professional development facilitator in relation to the project and assure the local school leaders of my continued support throughout the professional development sessions, as well as any needed support during follow-up PLC sessions. In my role as professional development facilitator, I will elicit the support and assistance of the local school's literacy and numeracy coaches, and also the technology specialist. These people can provide valuable resources that can enhance the project presentation.

Project Evaluation Plan

Evaluation for the project deliverable will be formative. At the close of each professional development session, participants will have opportunities to evaluate their learning experiences. Participants will be asked to provide any questions and concerns regarding the presentation and implementation of the strategies and resources for integrating mathematics across the curriculum, as well as any suggestions for future sessions involving mathematics integration. A part of this evaluation process will be the anticipated follow-up PLC sessions, during which teachers will have opportunities provide feedback on the implementation of instructional activities in relation to strategies and resources presented during the initial professional development sessions. Changes in teacher attitudes and beliefs about adopting new instructional approaches often take place after implementation of such approaches, due to evidence of increased improvement in student learning outcomes (Guskey, 2002). Formative assessment is a process for increasing teacher confidence and competence for effecting improved student learner outcomes (Guskey, 2002).

A formative evaluation process has been chosen for this project because change in teachers' instructional practices needs ongoing support and leadership (Whitworth and Chiu, 2017). The purpose of teacher learning is to improve classroom instructional practices for the ultimate goal of improving student achievement (Smith 2013). According to Smith (2013), teachers need to receive feedback about implementation of new instructional practices via discussion with colleagues and external consultants.

These discussions will assist teachers with developing personal understanding of the practices within a supportive environment. Teachers must develop ownership of the changes in their instructional practices as they determine whether such changes are positively impacting student achievement (Smith, 2013; Verberg, Tigelaar & Verloop, 2013).

Formative assessment assists teachers with planning and implementation of new instructional approaches, assessing the effectiveness of such approaches, targeting areas of instructional practice that need revision, and developing plans of improvement for those targeted areas (Guskey, 2002; Verberg et al., 2013). Smith (2013) asserted that teachers need to be encouraged to implement new instructional practices to meet local school and district requirements without succumbing to external standardized assessment pressures. According to Smith (2013), assessment results should be used as a pedagogical tool for continuous teacher learning.

The overall goal of this evaluation is to assist non-STEM teachers with meeting the requirement of integrating mathematics into their lesson activities by providing interactive activities, strategies and resources focused on increasing their self-efficacy for integrating mathematics with their specific, individual subject areas. Evidence of non-STEM teachers' increased efficacy for integrating mathematics into their instructional activities will be indicated by their persistence in planning interdisciplinary lessons that incorporate mathematics applications, their perseverance with collaborating and planning with mathematics teachers to implement such lessons, their positive feedback regarding implemented lessons and student progress, and their willingness to target those areas in relation to mathematics integration that need revision. All of these processes will be indicators of non-STEM teachers' growth in confidence and competence for integrating mathematics into their instruction.

Project Implications

The findings of my study indicate a need for increased communication and collaboration between the local school's non-STEM and STEM faculty members. Implementation of my project could bring about increased communication and collaboration about how to help students strengthen and apply their STEM competencies across the curriculum. Planning and implementing interdisciplinary lessons can strengthen the local school's educational environment and assist the school with achieving its academic mission and goals.

In a broader context, the study findings may bring about social change by raising awareness for the need for more consistent teacher professional development related to STEM education. Since STEM education is now a focal point for paving the way to keeping the United States globally competitive, teachers must be better prepared with the strategies and resources that will help them create meaningful STEM learning experiences that simulate real world situations. Acquiring STEM knowledge and skills are critical to acquiring and building a successful career in the 21st century.

The following section contains my reflections and the study conclusions. It addresses the project's strengths and limitations, as well as recommendations for alternative approaches. It also contains comments on scholarship, project development, and leadership and change and a discussion regarding the project implications, applications, and directions for future research.

Section 4: Reflections and Conclusions

Introduction

The goal of this study was to explore non-STEM teachers' self-efficacy for integrating mathematics across the STEM charter high school's curriculum. Participants offered their perspectives about integrating mathematics into their instruction via in-depth interviews which revealed valuable insight about their self-efficacy (confidence, competence, motivation, perseverance and persistence) for integrating mathematics across the curriculum. Based on the participants' responses, a professional development project was developed to strengthen non-STEM teachers' efficacy for integrating mathematics into their instructional activities. Project components were designed to align with the study participant's interview responses.

Project Strengths and Limitations

Project strengths include the following: components that are aligned with the data analysis results; components that are supported by research found in the literature review in Section 3 of this study; content area literacy strategies that are foundational to improving mathematics learning; interactive activities, some of which are transferrable to classroom practices; a design that promotes sustainability of professional development training via weekly PLC sessions. Non-STEM teachers will have opportunities to improve their efficacy for integrating mathematics into their instructional activities by engaging in interactive activities that involve content area literacy strategies that are foundational to all subject areas. Emphasis will be placed on how those strategies can be used in mathematics problem solving and applications. Non-STEM teachers will also have opportunities to collaborate with mathematics teachers and consultants to develop interdisciplinary lessons that include mathematics applications. Teacher collaboration related to those lessons will be extended in the context of lesson evaluations and reflections during the weekly PLC sessions.

The literature associated with this project indicated that professional development has a positive influence on teacher efficacy (Yoo, 2016), and can lead to more effective teacher planning and implementation of student lesson experiences (Corkin, 2015). This project may be limited in its ability to address all the perspectives of the local school's non-STEM teachers, because not all the non-STEM teachers currently on staff at the school agreed to participate in the study. However, the academic environment of the local school should improve as teachers collaborate to plan and implement quality interdisciplinary lessons that can help students connect their knowledge and skills across subject areas.

Recommendations for Alternative Approaches

The problem in this study is that non-STEM teachers at the local school are required to integrate mathematics into their instructional activities. Some of these teachers may not have the efficacy and background knowledge to meet the requirement of integrating mathematics into their content areas. This problem could have been addressed differently by focusing on non-STEM teachers' value beliefs about mathematics as a subject area needed in real life and its importance to students preparation for college and career paths. Non-STEM teachers' attitudes about the value of learning mathematics can influence students' motivation, value beliefs and attitudes about learning mathematics. The study problem could have been defined in relation to how non-STEM teachers' value beliefs about mathematics learning impact their ability to integrate mathematics across the curriculum. Problem solutions may have been found in the reasons behind negative beliefs and ways to motivate positive changes in those beliefs to improve their persistence with integrating mathematics into their content areas. A change in value beliefs can increase a teacher's level of efficacy. Professional development training could be developed with emphasis on the value of mathematics in real life, its applications in other content areas, and how it impacts future college and career paths.

Scholarship, Project Development, and Leadership and Change

Scholarship

As I engaged in the research process, I learned about several major requirements that are essential to developing a quality study. Once a study topic is selected, the problem, purpose, conceptual framework, and research questions must be aligned. The conceptual framework is the basis for that alignment. The literature review must be grounded in the conceptual framework and contain synthesized information centered around the main ideas related to the problem. Research that may be indirectly related to the topic but not directly related to the problem or the conceptual framework should not be included in the literature review. Also, information included in the literature review should not reflect researcher biases or opinions.

I found that the methodology design must be carefully selected in order to ensure access to information needed to inform the research questions and the problem solutions. For a qualitative design approach, research questions must be carefully crafted to access relevant information from the study participants that will inform the research questions and lead to problem solutions. The literature review associated with the project should reflect the data analysis results and support the design of the project. Quality literature reviews must be supported by peer reviewed sources, current articles (within 5 years of study completion), and reflect a saturation of information related to the topic or in support of the project.

During the data collection process, I learned how to stay objective about the process, not letting researcher biases interfere with listening to study participants' perspectives. I also learned how to elicit more detailed information from participants as needed for clarity of the responses. As I engaged in the data analysis process, I learned how to organize the data by identifying codes and themes to categorize the data. Member checks were utilized to ensure accurate reporting of the data. Finally, I listened intently to my peer reviewer, external auditor, and doctoral committee's insights about my interpretation of the data to ensure accuracy in my data analysis results.

Project Development

I selected the project genre of Professional Development/Training Curriculum and Materials because it was the most appropriate one for addressing the needs expressed by non-STEM teacher study participants in relation to integrating mathematics into their instructional activities. The project is designed to engage non-STEM teachers in interactive and collaborative activities that will hopefully increase their levels of efficacy for integrating mathematics across the curriculum.

Though I have had some experiences with facilitating portions of workshops, I have never had to plan all aspects of a professional development workshop from beginning to end. While planning the workshop sessions, in my mind I put myself in the participant's place to try to develop activities that would be meaningful and useful in classroom practices. I have facilitated and participated in many workshops. I used my dual perspectives as workshop facilitator and participant to hopefully increase the quality of the professional development project components. Evaluation for the professional develop training will be ongoing, so that I can address questions and concerns which may lead to improvement in the session presentations.

Leadership and Change

As a scholar, I still have a lot to learn about becoming a researcher and definitely more about writing and reporting the research. I need to know more about synthesizing the information and selecting the most appropriate articles. Conducting the research for my study has been agonizing at times, but overall an enriching experience. As a practitioner, I have gained information through my research about classroom practices and teacher collaboration that I wish I had been aware of during my tenure in the classroom. Since I am currently retired from teaching, I plan to use what I've learned during my doctoral journey to possibly mentor other teachers, or become a consultant to a company that markets educational resources and programs. As a project developer, I can use what I learned from my study to increase awareness about the need for more professional development related specifically to mathematics and STEM education overall and possibly plan workshops for schools in the local district. Hopefully, I can be instrumental in changing educators' attitudes about the importance of learning mathematics and its usefulness in the real world.

Reflection on the Importance of the Work

Exploring non-STEM teachers' self-efficacy about integrating mathematics across the curriculum revealed many aspects related to mathematics teaching and learning. As I expected, some of the study participants had bad experiences with learning mathematics and those experiences impact their efficacy for integrating mathematics into their instruction. Others said they like mathematics, but did not recognize the importance of learning mathematics in regard to the 21st century job market. Some of the other participants expressed regret about not taking the opportunity to learn more mathematics when they were in school, because now they are faced with having to encourage and help their own children with becoming better mathematics achievers. Surprisingly, at least three of the study participants had experiences with teaching mathematics on the elementary and middle school levels, prior to becoming part of the local school's staff. These teachers' interview responses revealed they taught mathematics without much conceptual understanding and real world connection. It is extremely important to expose educators on all levels to consistent mathematics professional development training to effect improvements in mathematics teaching and learning and to prepare students for successful college and career paths.

Implications, Applications, Directions for Future Research

Increased teacher professional development involving integration of mathematics across the curriculum is needed to assist student with connecting their mathematics learning across the curriculum and to the real world. Teachers must encourage students to have more positive attitudes about learning mathematics and give them opportunities to learn about and experience real world mathematics connections. Implementation of the strategies and resources incorporated in the project for this study can lead to a more cohesive and positive learning environment in the local school. The project developed for this study could also be used to promote improvements in STEM learning environments in other schools. When students understand more about how mathematics connects to real-life, it may be the beginning of changing some of society's negative attitudes about mathematics learning. More research is needed about how to change society's tolerance of innumeracy, while being readily intolerant of illiteracy.

Conclusion

Conducting this project study revealed the disconnections that still exist between the importance of learning mathematics and the importance of learning other subject areas. We need to invest in resources for mathematics teaching and learning in the same manner that we invest in reading and language arts resources. Engaging teachers in mathematics professional development is a start for improving not only educators but society's attitudes about the importance mathematics learning. Improving the quality of mathematics education is critical to improving the quality of STEM learning, as mathematics offers foundational support in relation to learning the other core STEM disciplines of science, engineering and technology. Improving mathematics education leads to increased quality of student achievement, as well as increased quality of their future lives.

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Appendix A: The Project

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Workshop Summary/Reflections/Review

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Introduction

This project was developed to assist non-STEM teachers with integrating mathematics across the curriculum. Each professional development module involves interactive activities designed to promote non-STEM teachers' collaboration with STEM teachers and literacy consultants, for the purpose of developing interdisciplinary lesson experiences that include mathematics applications.

Purpose

The purpose of this project is to increase non-STEM teachers' efficacy for integrating mathematics into their instructional activities. During the professional development sessions, non-STEM teachers will have opportunities to increase their confidence and competence with integrating mathematics into their instruction by collaborating with mathematics teachers to use the strategies and resources presented in the professional development sessions to plan and implement interdisciplinary lessons that include mathematics applications. Non-STEM teachers will be motivated to persevere with integrating mathematics into their content areas by having time in weekly professional learning community sessions to evaluate and reflect on those implemented interdisciplinary lessons and their impact on student achievement. Continued collaboration between STEM and non-STEM teachers may lead to overall improvement of the local school's STEM educational environment, as well as increased student progress. Activities included in the professional development training sessions are standards based and include standardized test-taking skills.

Intended Audience

The initial audience for this project will be the local school's administrators and consultants. A Power Point presentation that outlines the study findings and proposed project will be presented for approval by the school's leadership. Upon approval from the school's leadership team, the professional development project will be implemented and presented to the local school's faculty during the fall staff development days. This project is relevant to both non-STEM and STEM faculty members, because of the needed increase in communication and collaboration between non-STEM and STEM teachers for the purpose of planning and implementing interdisciplinary lessons that incorporated mathematics applications. Increased collaboration among faculty members of the local school will help the school meet its academic goals and achieve its mission and vision of preparing students to adopt a STEM pathway to college and careers.

Implementation Timeline

Module	Activities	Resources	Timeline
Module 1: The STEM Educational Environment	Review characteristics of the STEM Educational Environment Identify instruction connection between non-STEM and STEM courses Engage in interactive activities that promote literacy and numeracy across the curriculum. Use literacy strategies to develop mini lessons that contain examples of mathematics applications integrated with another content area	School multipurpose room Smart Board/projector Large chart paper and markers Sign-In sheet Agenda Evaluation Form	August 3 hours
Module 2: Mathematics: A Valuable Tool	Read and discuss passages involving the value of mathematics and the consequences of mathematical illiteracy. Review Problem Solving Techniques Practice with problem solving techniques using problems with real-world connections Review strategies for integrating mathematics into individual content areas Plan and present mini lessons that can be used to integrate mathematics with specific content areas, and that incorporate literacy strategies and problem solving	School multipurpose room Smart Board/projector Large chart paper and markers Sign-In sheet Agenda Evaluation Form	August 3 hours

	techniques		
Module 3: Teacher Collaboration and Team Teaching	Identify strategies for teacher collaboration and team teaching. Collaborate with a mathematics teacher or consultant to plan interdisciplinary mini lessons that connect your content area and mathematics to the real world Team teach to present mini lessons Evaluate and reflect on mini lessons using focused collaboration and reflection approaches	School multipurpose room Smart Board/projector Large chart paper and markers Sign-In sheet Agenda Evaluation Form	September 6 hours
Module 4: Interdisciplinary Lesson Planning	Review standards documents to identify content-area topics that connect to mathematics applications. Collaborate in teams that have both non-STEM and STEM teachers to plan interdisciplinary lessons that include literacy strategies, problem solving techniques, real world connections and mathematics applications, and can be implemented during the first semester. Identify appropriate technology tools that can be used in those lesson presentations. Present interdisciplinary lesson plans.	School multipurpose room Smart Board/projector Large chart paper and markers Sign-In sheet Agenda Evaluation Form	October 6 hours

Welcome Please Sign In
Integrating Mathematics Across the Curriculum

Topic: The STEM Educational Environment
Facilitator: Sandra Burrell
Date: ___________________________
Time: ___________________________

NAME (Print)	SIGNATURE

Module 1 – The STEM Educational Environment

Objectives: By the close of this session teachers will be able to:

- Identify the characteristics of a STEM educational environment
- Identify instruction connections between non-STEM and STEM courses
- Plan and implement interactive activities that promote literacy and numeracy across the curriculum
- Use literacy strategies to develop content-area lessons incorporating mathematics applications

MODULE 1: THE STEM EDUCATIONAL ENVIRONMENT
AGENDA

9:00 AM – 10:00 AM - Introductions

- Sign –In
- Project Overview Power Point
- Write Thoughts About Innumeracy and Illiteracy
- How Did You Use Mathematics This Week
- Review Characteristics of the STEM Educational Environment

10:00 AM – 11:00 AM – Connections Across the Curriculum

- Identify Instructional Connections Between Non-STEM and STEM Courses
- Content-Area Literacy and Numeracy Strategies
- Sample Lesson Using Content-Area Literacy and Numeracy Strategies

11:00 AM – 12:00 PM – Interactive Activities

- Create Content-Area Mini Lessons Incorporating Literacy and Numeracy Strategies
- Sample Mini Lesson Presentations
- Evaluation

(See Appendix E for Sample Module Interactive Activity Details)

Welcome Please Sign In
Integrating Mathematics Across the Curriculum

Topic: Mathematics: A Valuable Tool
Facilitator: Sandra Burrell
Date: ___________________________
Time: ___________________________

NAME (Print)	SIGNATURE

Module 2 – Mathematics: A Valuable Tool

Objectives: By the close of this session teachers will be able to:

- Identify reasons for integrating mathematics across the curriculum
- Identify and practice mathematics problem solving techniques
- Identify and practice strategies for integrating mathematics in specific non-STEM content areas
- Plan and present mini lessons that incorporate problem solving techniques and literacy strategies and that can be used to integrate mathematics into specific content areas

MODULE 2: MATHEMATICS: A VALUABLE TOOL

AGENDA

9:00 AM – 10:00 AM - Introductions

- Sign –In
- Brief Review of Module 1
- Consequences of Innumeracy (Mathematical Illiteracy)

10:00 AM – 11:00 AM – Problem-Solving Techniques Across the Curriculum

- Identify Problem –Solving Techniques
- Use of Problem-Solving Techniques in the Content-Area
- Sample Lesson Using Problem-Solving Techniques
- Strategies for Integrating Mathematics Into Other Content Areas

11:00 AM – 12:00 PM – Interactive Activities

- Create Content-Area Mini Lessons Incorporating Mathematics Applications (Include Problem-Solving Techniques, Literacy and Numeracy Strategies)
- Present Mini Lessons
- Evaluation

(See Appendix E for Sample Module Interactive Activity Details)

Welcome Please Sign In
Integrating Mathematics Across the Curriculum

Topic: Teacher Collaboration and Team Teaching
Facilitator: Sandra Burrell
Date: ___________________________
Time: ___________________________

NAME (Print)	SIGNATURE

Module 3 – Teacher Collaboration and Team Teaching

Objectives: By the close of this session teachers will be able to:

- Identify strategies for teacher collaboration and team teaching
- Collaborate to plan and implement lessons involving mathematics applications
- Team teach to present lessons

MODULE 3: TEACHER COLLABORATION AND TEAM TEACHING

AGENDA

9:00 AM – 10:00 AM - Introductions

- Sign –In
- Brief Review of Module 2
- Strategies for Engaging in Teacher Collaboration and Team Teaching

10:00 AM – 12:00 PM – Lesson Planning

- Collaborate with mathematics teachers and consultants to create content-area lessons incorporating mathematics applications (Include Problem-Solving Techniques, Literacy and Numeracy Strategies).

1:00 PM – 3:00 PM – Lesson Presentations

- Team Teach To Present Lessons

3:00 PM – 4:00 PM

- Evaluate and reflect on lesson presentations using focused collaboration and reflection approaches
- Module 3 Evaluation

(See Appendix E for Module 3 Activity Details)

Welcome Please Sign In

Integrating Mathematics Across the Curriculum

Topic: Interdisciplinary Lesson Planning
Facilitator: Sandra Burrell
Date: ___________________________
Time: ___________________________

NAME (Print)	SIGNATURE

Module 4 – Interdisciplinary Lesson Planning

Objectives: By the close of this session teachers will be able to:

- Identify non-STEM content-area topics that connect to mathematics applications
- Collaborate to plan interdisciplinary lessons that incorporate mathematics applications and that can be implemented during the first semester
- Identify technology resources and tools to enhance lessons
- Present interdisciplinary lesson plans

MODULE 4: INTERDISCIPLINARY LESSON PLANNING

AGENDA

9:00 AM – 10:00 AM - Introductions

- Sign –In
- Brief Review of Previous Modules
- Review Standards Documents to Identify Content-Area Topics that Connect to Mathematics Content Areas

10:00 AM – 11:00 AM – Technology Tools

- Identify Technology Tools to Enhance Lessons

11:00 AM – 12:00 PM – Lesson Planning

- Present Exemplar Interdisciplinary Lesson
- Collaborate in Interdisciplinary Teams to Plan Lessons that Incorporate Mathematics Applications

1:00 PM – 3:00 PM – Planning and Presentations of Lessons

- Complete Interdisciplinary Lesson Planning
- Lesson Presentations

3:00 PM – 4:00 PM – Evaluation and Reflections

- Review – Self Evaluate (Revisit Project Overview Power Point)
- Summary
- Project Evaluation

(See Appendix B for Module 4 Activity Details)

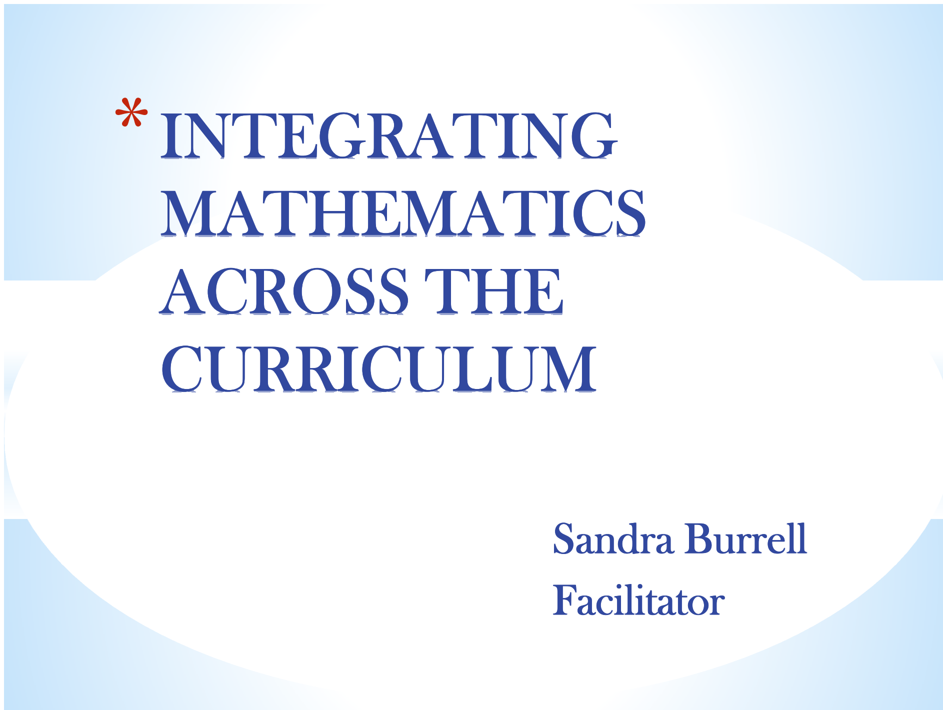
Integrating Mathematics Across the Curriculum
Professional Development
Evaluation

Facilitator ______________________ Topic ___________________________
Date: _______________________

Directions: Please evaluate today's session on a scale of 1-5 with 5 being the highest score.

		1	2	3	4	5
Planning	**Individual Needs Assessment**: Attendance at this session meets my individual needs for professional development.					
	Content: Content relevant to my needs for integrating mathematics into my instructional activities.					
Delivery	**Relevance of Professional Development:** The training objectives for this session were aligned to the topic.					
	Learner Outcomes: The learner outcomes were presented and accomplished during this session.					
Value	**Transfer to Students**: I'll be able to use the knowledge and skills learned in this training to improve student achievement.					
Implementation	**Lesson Planning:** I plan to utilize the concepts taught in my lesson planning and design.					
	Collaboration: I plan to collaborate with teachers and consultants to implement interdisciplinary lessons that incorporate mathematics applications.					
Comments/Questions						

The Project Power Point



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Appendix B: Survey-Mathematics Integration

Survey: Mathematics Integration (Responses)

1. How often do you include math related activities in your lesson plan?

   *Teacher 1***:** I try to include math related activities from time to time, maybe once a month. It is difficult at times to integrate the two subjects.

   Teacher 2: Very rarely is math specifically integrated into my English lesson plans.

   Teacher 3: I try to incorporate math related activities into my lessons when it is appropriate. Example-When teaching the book, Copper Sun (A book about horrors of the Middle Passage) by Sharon Draper, I used the number of the ships that made the trips, the casualties that occurred mid-passage and the survivors that came to America, to show the children the strength of the people that made it to the shores of this country. The children compared, contrasted and calculated factors that could impact the slaves, and added these things into their assessment of the strength of the people.

   Teacher 4: Not often.

   Teacher 5: I use math in my lesson at least two times a week.

2. What assistance, as mathematics resource coordinator can I give you with incorporating mathematics activities into your instruction?

   Teacher 1: There are many ways that it could be helpful to have support in incorporating math activities into my instruction. Doing a professional development session would be a great way to go through a variety of different strategies and would be useful if any questions remained.

   Teacher 2: You could give me more ideas about how to incorporate math activities into my instruction.

   Teacher 3: I need help integrating math into literature. As a purely right brained, whole picture kind of person, I don't know how to combine the finite possibilities of math into literature.

   Teacher 4: Finding creative games and activities to incorporate based on the lesson.

Teacher 5: We could plan a lesson which uses components of history and math.

3. What resources do you need to help with integrating mathematics into your lesson activities?

   Teacher 1: More articles that relate to science and math would be helpful. It is necessary to read a lot of non-fiction, so it would be a great opportunity to read articles that make the students think quantitatively.

   Teacher 2: You could provide me with non-fiction articles (and questions) for my students to read and answer. These articles should involve reading text on grade level with content that is about math topics or about math operations, statistical evaluation or mathematicians.

   Teacher 3: Maybe manipulatives would help.

   Teacher 4: More technology.

   Teacher 5: Listing of careers that are math related, math handouts which could be used for warm-up activities.

4. What strategies are you currently using to help students make connections between your discipline and mathematics?

   *Teacher 1***:** The most important thing I am doing is trying to take time to think about math when a situation presents itself. If we are discussing current events, for example, then we can think about potential math problems that come up in those certain instances. It's really about being proactive in thinking about integrating the two subjects.

   Teacher 2: Students are required to analyze graphs and tables in non-fiction articles. Questions for groups of students or as part of a Socratic seminar or classroom discussion or in a question based discussion are typically how connections are made between the mathematics and readings. Students often integrate information from mathematical sources into their essays, particularly on AP Language source essays.

   Teacher 3: What I said previously. I definitely need help.
   Teacher 4: Using real world examples such as when shopping and using comparisons.

   Teacher 5: When we discuss demographics as it relates to population, I have students create math equations using percentages, simple addition, subtraction, etc.

Appendix C: Interview Questions

Non-Science, Technology, Engineering, Mathematics Teachers' Efficacy
For Integrating Mathematics Across the Curriculum

Interview Questions

1. What courses are you currently teaching here at the school?

2. What is your major field of study?

3. What personal background experiences with learning mathematics have had an influence (positive or negative) on your sense of confidence when it comes to integrating mathematics into your instruction?

4. How would collaborating or team teaching with a mathematics teacher affect your sense of confidence when it comes to integrating mathematics into your instruction?

5. Has professional development on integrating mathematics across the curriculum increased your sense of confidence when it comes to integrating mathematics into your instruction? Why or why not?

6. How would collaborating or team teaching with a mathematics teacher influence your competence for integrating mathematics into your instruction and into your course content?

7. How can professional development on integrating mathematics across the curriculum increase your competency for integrating mathematics into your lesson activities?

8. How does teaching in a STEM educational environment influence your motivation for integrating mathematics into your instructional activities?

9. How would team teaching or collaborating with a mathematics teacher affect your motivation for integrating mathematics into your instruction and/or course content?

10. How do you value mathematics as a subject area needed in real life and how does this influence your motivation for integrating mathematics into your instruction?

11. What factors (positive or negative) influence the frequency with which you integrate mathematics in to your instruction?

12. If you repeatedly tried to integrate mathematics applications into your instruction without positive results (i.e. students are still unable to correctly apply the math concepts to the lesson), what would you do?

13. What factors are needed in professional development sessions on integrating mathematics across the curriculum to influence your persistence with integrating mathematics into your instruction?

14. How would collaborating or team teaching with a mathematics teacher help overcome problems you may encounter with integrating mathematics into your instruction and influence your persistence with integrating mathematics into your course content?

Appendix D: Interview Protocol

Project: Non-Science, Technology, Engineering, Mathematics Teachers' Efficacy For Integrating Mathematics Across the Curriculum

Time of Interview: _______________________

Date: ____

Place: ____

Interviewer ____________________________________

Interviewee: ______________________________________

Position of Interviewee (Brief Background: instructional subject area, years of experience, etc.)

Project Overview: The goal of this study is to explore non-STEM teachers' self-efficacy for integrating mathematics across the STEM charter high school's curriculum. Data from this interview was utilized to answer the research questions related to the study. All responses were recorded to ensure accuracy of the information. All responses will be kept confidential.

Interview Questions and Responses:

Researcher Reflections

Appendix E: Sample Professional Development Activities

Module 1 – Sample Activities

Activity 1: How Did You Use Mathematics This Week?

Participants will write their responses on post-its and place them on a large wall poster. This display will be used as a reminder during the session of the importance of learning mathematics and its usefulness in everyday life.

Activity 2: Literacy and Numeracy Skills

Given a worksheet containing lists of literacy and numeracy skills, participants will be asked to create checklists showing where they think each of the skills may be used. A discussion about the checklists will show how these skills can be utilized across the curriculum

Activity 3: Community Population Growth (Mathematics and Social Studies)

Given a graph displaying population growth for communities within the school district, participants will be asked to use the information found in the graph to determine answers about the population growth and how it might affect the school's population if the future.

Module 2 – Sample Activities

Activity 1: Fast Food Choices (Mathematics and Health and Wellness)

Part 1

1. Have participants select their favorite fast food restaurant with the use of sticky dots (A chart will be provided).
2. Based on the data displayed, teachers can calculate the most popular fast food restaurant choice.
3. Create graphs by calculating the percent of participants who preferred each choice.

Part 2

1. Display popular menu choices from each fast food restaurant.
2. Have participants select their favorite menu item using the sticky dots
3. Participants will calculate the most popular menu item from each restaurant, based on the data displayed.
4. Create graphs based on the data.
5. Facilitator will provide nutrition facts about menu choices.
6. Participants can answer questions about their choices.

For Example: (Which restaurant offers the best menu nutrition wise? What effect will you constantly eating your menu choice have on your body? Which restaurant do you think contributes the most to the obesity problem in the U.S. and why?).

Activity 2: Math Story Activity (ELA and Mathematics)

Participants will read a short math story and answer questions that contain math problems related to the story. There will be three story problem sets of questions available with varying levels of difficulty. In a classroom setting teachers will be able to modify the problem sets by increasing or decreasing the number of questions based on the desired learner outcomes. ELA teacher and math teachers can collaborate to write questions that accompany the stories that emphasize the skills they want students to learn in both content areas. Students can work in groups to solve the problems related to the stories. An extended classroom activity might be to have students create their own stories and related questions for their peers to answer. The teacher can provide a story guideline rubric for students.

*(**Note**: Module 2 activities incorporate problem solving techniques, literacy and numeracy strategies)*

Module 3 – Sample Activities

Activity 1: The Human Boxplot

(Mathematical Literacy-Visualizing Mathematics Vocabulary**)**

Vocabulary: boxplot, five number summary (*minimum, 1st quartile, median, 3rd quartile, maximum*)**,** range**,** variable**,** data

1. Define boxplot, variable, and the Five Number Summary
2. Demonstrate how to calculate the Five Number Summary on the life size boxplot model.
3. Have teacher participant volunteers line up in order according to their years of teaching experience (volunteers will display their years of experience on poster cards).
4. Teachers in the audience can calculate the five number summary based on the data provided and complete boxplot worksheets.
5. Teacher volunteers can form a human boxplot based on calculations provided by the teachers in the audience (facilitator will monitor calculations).

*(**Note:** The boxplot is usually one of the graphs included in problems found in the math portion of state tests.)*

Activity 2: Collaboration and Connections

(Integration of Mathematics with Other Content Areas)

Participants will divide into departments and create lessons that use content from their individual subject areas and mathematics applications. Mathematics teachers will rotate from group to group to assist teachers in other departments with creating their lessons. Prior to this session the facilitator will compile a bank of real world problems that connect to various content areas and incorporate mathematics applications. This problem bank will only be used if teachers have difficulty initiating the planning of their lessons. Teachers will be encouraged to include problem solving techniques, literacy and numeracy strategies in their lessons.

Module 4 – Sample Activities

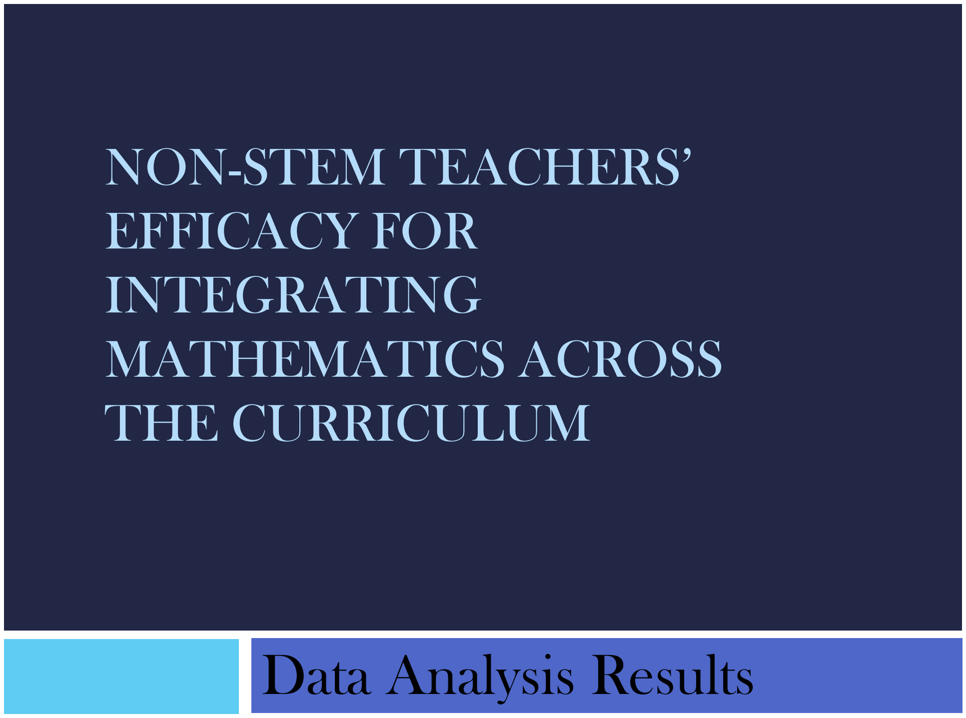
Activity 1: Interdisciplinary Lesson Exemplar

Facilitator will prepare and present and interdisciplinary lesson that incorporates standards, objectives, technology, problem solving techniques, literacy and numeracy strategies.

Activity 2: Interdisciplinary Lesson Planning

Participants will divide into interdisciplinary teams to collaborate and plan interdisciplinary lessons that incorporate the components of the exemplar lesson. Lessons will be presented during the professional development session. Participants will have opportunities to reflect how the lessons presented may be used with students in their classrooms.

Appendix F: Data Analysis Power Point



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