University of Nevada, Reno

Elementary Teachers' Receptivity to Integrated Science, Technology, Engineering, and Mathematics (STEM) Education in the Elementary Grades

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by

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Abstract

This study examines elementary teachers' receptivity to integrated Science, Technology, Engineering, and Mathematics (STEM) education in the elementary grades prior to formal approval and declaration of its implementation in elementary schools. A 35-item, seven-point Likert scale survey instrument, adapted from Waugh and Godfrey's (1993, 1995), and Lee's (2000) receptivity to change instruments, was formatted, uploaded, and distributed online. In addition, face-to-face interviews were conducted to support, clarify, and/or extend quantitative data. Analyses revealed that overall elementary teachers' receptivity was positive to integrated STEM education in the elementary grades. Further, analyses revealed that novice teachers had significantly more positive attitude than veteran teachers to integrated STEM education in the elementary grades, general education teachers had significantly more positive attitude and behavior intentions than did special education teachers, and intermediate grade-level teachers had significantly more positive behavior intentions than primary grade-level teachers.

Analyses revealed strong positive relationships between each dependent variable (attitude and behavior intentions) and two of the independent variables (perceived school and other types of support and perceived practicality), and each dependent variable showed a strong negative relationship with teachers' issues of concern. In addition, a significant proportion of the variation in teachers' attitudes and teachers' behavior intentions was predicted by the linear combination of teachers' issues of concern associated with implementing integrated STEM education, perceived school and other types of support, and perceived practicality of integrated STEM education in the elementary grades.

Finally, qualitative data, in support of quantitative data, revealed that elementary teachers possess initial positive receptivity to implementing integrated STEM education in the elementary grades. Analysis further revealed elementary teachers' perceived obstacles to and they provided insightful perspectives on how best to achieve short and long-term success for implementing integrated STEM education into the elementary grades.

Dedication

To my Heavenly Father, all things are possible in you. The Lord is my strength and my shield; my heart trusted in Him, and I am helped (Psalm 28: 7a New King James). To my wife Lisa who made sense when the pursuit did not. To my children, Tyler and Taryn, who have sacrificed their time with dad but love me all the same. To all that have prayed, encouraged, and supported me and have contributed to this work along the journey.

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Chapter One

Introduction

U.S. citizens find themselves at a critical juncture in history. Today, more than ever, their international peers are developing science, technology, engineering, and mathematics (STEM) skills at a soaring rate for the purpose of producing innovative products that will allow them to compete in the global market place (Bybee & Fuchs, 2006; National Research Council, 2007). For example, China and India produce a high number of engineers every year; combined, they prepared approximately one million engineers in 2004 (Ehrlich, 2007). However, the number of U.S. college students pursuing and completing undergraduate STEM degrees is far below that of other countries (DeJarnette, 2012). Over the past two hundred years, the United States has maintained an economic advantage over much of the world because of engineering and science initiatives. However, times are changing; foreign competitors are capable of challenging the U.S. in providing the world with innovation. National ingenuity is more necessary today than in times past to stay internationally competitive. Greater knowledge of the STEM fields by U.S. citizens is paramount in the 21st century in order to continue national advancement and maintain international leadership in innovation (National Science Board, 2007).

Producing a competent STEM workforce must start by providing all students with STEM education that is well defined and aligned throughout the K-16 grade levels (National Science Board, 2007). In STEM education as an integrated concept, the STEM content areas should intersect across their formerly rigid borders. This integration should be implemented using real world, problem-based learning strategies within a standards-

based curriculum (Breiner, Johnson, Harkness, & Koehler 2012; Sanders, 2009). Merrill and Daugherty (2010) view integrated STEM education as an integration of science and mathematics content taught through engineering and technology lessons and units. Further, Merrill (2009) identified integrated STEM education as standards based curriculum that focuses on integrating science, technology, engineering, and mathematics.

Ehrlich (2007) defined *competitiveness* as "an economy's ability to generate high-wage jobs and support a high and rising standard of living" (p. 1). Ehrlich (2007) posits that innovation is the way to maintain *competitiveness* and prevent economic stagnation and decline in the U.S. Therefore, integrated STEM education provides an azimuth to produce the next generation of scientists, engineers, and mathematicians to keep the U.S. in the forefront of scientific discovery. Future innovators in these fields will continue to reinvent and create new technology that will ultimately produce better-paying jobs; this is one way of maintaining or improving citizens' standard of living, which often reciprocally benefits the nation's economy.

Many recognize that integrated STEM education can be the means by which to accomplish the task of preparing students with the necessary 21st century skills to fill jobs in high-tech fields (National Science Board, 2007). Simply put, there are not enough STEM-trained Americans to meet current job demands by U.S. employers (Barakos, Lujan, & Strang, 2012; Merrill & Daugherty, 2010). Park (2011) suggests that as many as 140,000 engineering-related jobs in the U.S. are outsourced to foreign-born job seekers because of the nation's current inability to produce its own. In 2005, fewer U.S. high school students than in times past identified engineering careers as a potential option for

future employment. Further, more students expressed negative attitudes toward STEM fields and content areas than in previous years (Mahoney, 2010). However, educators, business leaders, and legislators recognize integrated STEM education initiatives as a national strategy to stimulate students' interest and to improve student STEM achievement, as well as the number of students in STEM programs of study, STEM degree graduates, and U.S. citizens working in STEM-related fields (National Science Board, 2007; Park, 2011).

The underproduction of a high-tech, STEM-trained citizenry in the U.S. has brought attention to the nation's K-12 education system (National Research Council, 2007). According to international assessments, such as the Trends in International Mathematics and Science Study (TIMSS; 2011) and the Programme for International Student Assessment (PISA; 2009), U.S. students' science and mathematics achievement is not on par with student achievement in other industrialized nations. For example, the number of U.S. students scoring at or above the advanced mathematics and science benchmarks is below that of other countries (NCES, 2011). In 2009, PISA results show that mathematics literacy for U.S. fifteen-year-olds is below and science literacy for the same age group is equal to the international average for participating countries (OECD, 2009). In addition, the National Science Board (2007) confirms that almost one in three U.S. college freshmen lack the basic skills to have success in entry-level college mathematics and science courses.

Statement of the Problem

The vast majority of integrated STEM initiatives for U.S. schools target secondary grade levels (DeJarnette, 2012; Murphy & Mancini-Samuelson, 2012).

Initially, integrated STEM education was intended for gifted-and-talented and highly motivated secondary students as a method to accelerate learning, to provide appropriate challenge, and to provide college preparation (Meyrick, 2011). More recently, many of the secondary integrated STEM education programs aim to reach a broader range of learners with the intention of arousing their interests and providing them with the valuable skill sets essential for pursuing STEM degrees in college (Barakos, Lujan, & Strang, 2012). Although most agree that secondary integrated STEM initiatives are essential, some suggest that by tailoring the focus to secondary grade levels we may be overlooking the benefits of early exposure to integrated STEM education in the elementary grade levels. This omission may be a missed opportunity to spark students' interests and achievement, as well as future course taking, in the STEM subject areas (Russell, Hancock, & McCullough, 2007).

Rarely are integrated STEM education initiatives solely designed for elementary grade levels (DeJarnette, 2012). There is some evidence that integrated STEM education is making its way toward elementary schools, trickling down from secondary school curriculum and programs (Hathcock, Stonier, Levin, & Dickerson, 2012). Some adamantly call for integrated STEM initiatives intentionally aimed at elementary grade levels. They argue that early exposure to STEM education is the best way to nurture positive impressions of integrated STEM content through real-world class experiences that mirror future employment tasks, providing future professionals with a genuine window into STEM-related working environments (DeJarnette, 2012; Murphy & Mancini-Samuelson, 2012; Walker, 2012). Even the youngest students are capable of learning and understanding basic STEM content (Walker, 2012). DeJarnette (2012)

contends that elementary students possess the cognitive capacity to participate in integrated STEM curriculum that incorporates student-directed problem solving. Further, elementary students' exposure to integrated STEM education positively increases their self-confidence and self-efficacy related to future STEM lessons and courses. Russell, Hancock, and McCullough (2007) affirm that exposure to integrated STEM education in the elementary grades may improve students' motivation to take higher-level mathematics and science courses in secondary school and college. Early experience can eliminate an unintended blindfold students may have due to limited exposure with integrated STEM content areas and job opportunities before they have to make judgments and decisions concerning their career paths. Finally, Lottero-Perdue, Lovelidge, and Bowling (2010) found that STEM education emphasizing engineering principles and hands-on and inquiry-based strategies positively affected the self-management of students who typically struggled with traditional lessons.

Change is not easy but may be required to provide education that continually adapts to prepare students to compete in national and global innovative job markets. The National Science Board (2007) has recognized that it will take the combined efforts of all those responsible for developing, initiating, implementing, and improving integrated STEM education in the United States. It is no surprise that teachers will play a significant role in this process. In fact, research has shown that teachers' receptivity to educational reform is a strong indicator for influencing successful or unsuccessful outcomes (Waugh, 2000; Yin & Lee, 2008). Empowering teachers by giving them a voice in the decision-making processes concerning changes that directly affect them, their students,

classrooms, and school environments may go a long way toward improving their receptivity to reform (Lee, Yin, Zhang, & Jin, 2011; Waugh & Godfrey, 1993, 1995).

As with any major educational reform, students and teachers are often the most influenced by curriculum change; therefore, their receptivity can greatly determine the success or failure of its implementation (Ha, Wong, Sum, & Chan, 2008; Lee et al., 2011; Waugh, 2000). Teachers' partnerships, collaboration, insight, and perceptions are important for productive school environments, especially during times of change. When policy makers and administrators view all contributors as valuable parts of a collective whole, a school culture of cohesive leadership and responsibility can ensue to best suit all parties affected by the change (Waugh & Collins, 1998). Providing opportunities for teachers to share their expertise and perspectives on how best to implement and improve new curriculum, as well as incorporating this input, can facilitate transitions and augment success (Waugh & Collins, 1998).

Several studies note the vital importance of incorporating integrated STEM education into the elementary grade levels (Brenner, 2009; Bybee & Fuchs, 2006; DeJarnette, 2012), and others stress the importance of implementing engineering concepts into the elementary grades (Bagiati, Yoon, Evangelou, & Nagambeki, 2010; Swift & Watkins, 2004). Several authors have provided insight into the benefits of integrated STEM education in elementary classrooms (Brophy, Klein, Portsmore, & Rogers, 2008; Hathcock et al., 2012; Lottero-Perdue, Lovelidge, & Bowling, 2010) and out-of-school-time programs (Walker, 2012). Other researchers have focused their attention on elementary STEM resources available to educators from leading organizations developing integrated STEM curriculum (Brenner, 2009) and STEM

resources available on the internet emphasizing engineering for elementary grade levels (Bagiati et al., 2010).

Integrated STEM education implementation is believed to be crucially important for maintaining the United States' global competiveness and preparing citizens to fill current and future high-tech jobs (Bybee & Fuchs, 2006; National Research Council, 2007). Integrated STEM initiatives have been developed and steps are currently being made to revamp the current U.S. educational system to include integrated STEM education in the K-12 grade levels (Brophy et al., 2008; Meyrick, 2011). Many argue that the best time to provide experience and positively influence students is in the elementary grades (DeJarnette, 2012; Murphy & Mancini-Samuelson, 2012). Because teachers have a key influence on the success of curricular change (Waugh, 2000; Yin & Lee, 2008), the purpose of this study is to investigate elementary teachers' receptivity to integrated STEM education prior to formal approval and declaration of integrated STEM education implementation in elementary schools. No previous study is known to have investigated elementary school teachers' receptivity to STEM education.

Purpose of the Study and Research Questions

In order to meet the scientific and technological demands of an ever-changing economy (National Science Board, 2010), initiatives have been set to introduce integrated STEM education into U.S. schools. On a small scale, integrated STEM education has been implemented into secondary schools, but the implementation of integrated STEM education has been largely ignored in elementary schools (DeJarnette, 2012). This study was designed to investigate elementary teachers' receptivity (general attitudes and behavior intentions) to integrated STEM education prior to formal approval and

declaration of its implementation in elementary schools. Receptivity is defined as a measure of elementary teachers' attitude and behavior intentions toward integrated STEM education in the elementary grades. Attitude is defined as a teacher's position toward integrated STEM education in the elementary grades, and behavior intentions is defined as a teachers' level of physical and verbal support or opposition toward integrated STEM education in the elementary grades. Further, this study explored the differences, if any, in elementary teachers' receptivity among selected subgroups determined by demographic sub-grouping (i.e., assigned grade level, teaching assignment, certified teaching experience, school Title I eligibility, and school STAR performance rating).

In addition, the study examined the relationships, if any, between elementary teachers' receptivity to integrated STEM education and their potential concerns associated with implementing integrated STEM education, perceived school and other types of support, perceived practicality of integrated STEM education in the elementary grades, and teaching experience. Further, the study investigated the amount of variability in teachers' attitude and behavior intentions (receptivity) by the linear combination of issues of concern associated with implementing integrated STEM education, perceived school and other types of support, and perceived practicality of integrated STEM education in the elementary grades. Finally, the study analyzed elementary teachers' perspectives, insights, and concerns regarding the implementation of integrated STEM education into elementary grades and how best to ease transition, should it occur. Specifically, the research questions are:

1. What is elementary teachers' degree of receptivity to implementing integrated STEM education in the elementary grades?

2. What differences, if any, exist among selected elementary teacher subgroups in receptivity to implementing integrated STEM education in the elementary grades?

3. What relationships, if any, exist between elementary teachers' receptivity to and potential concerns associated with implementing integrated STEM education in the elementary grades and their perceived school and other types of support, perceived practicality of implementing integrated STEM education in the elementary grades, and teaching experience?

4. What are elementary teachers' perceptions toward the possible implementation of integrated STEM education in the elementary grades?

Definition of Terms

Receptivity

A measure of attitude and behavior intentions regarding reform (adapted from Lee, 1998)

Positive Receptivity

Scale index score (Mean score) above 4.0 on both the attitude and behavior intentions indices

Negative Receptivity

Scale index score (Mean score) below 4.0 on either, or both, the attitude or behavior intentions indices

Attitude

An overall position toward reform (adapted from Waugh & Godfrey, 1993)

Behavioral Intentions

Level of physical and verbal support or opposition toward reform

Perceived Practicality

Views about whether or not integrated STEM education will fit students' learning needs, the instructional style of the school and classroom, and participants' teaching philosophy

Perceived School and Other Types of Support

School: Teachers' concerns about whether a community of support exists in the school of current employment for professional assistance and development that would assist transition to integrated STEM education

Other: Teachers' perceptions of whether a community of support exists among their peers, administrators, and students' parents in the event that integrated STEM education is implemented in the elementary grades

Issues of Concern Associated with Implementing STEM Education into the Elementary Grades

Teachers' worries about student achievement, curriculum alignment to Common Core State Standards (CCSS) and/or state standards, classroom management issues, neglect of other important content areas, and current STEM knowledge

Elementary Teacher

A certified teacher working full or part time at an elementary school (K-5 or K-6)

Integrated STEM Education

An interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons where students apply science, technology, engineering, and mathematics in contexts that make connections among school, community, work, and

global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy (Tsupros, Kohler, & Hallinen, 2009); in addition, teaching and learning should include the blend of three or more of the STEM content areas (Park, 2011).

Significance of the Study

Never before has there been more need to prepare students for the STEM fields than today. Skill development in these fields is increasingly crucial for U.S. citizens to compete within the global workforce (National Science Board, 2010). Although it is argued that the elementary grade levels are the best time to stimulate interest in, connections to, and motivation for the STEM fields (DeJarnette, 2012; Russell, Hancock, & McCullough, 2007), initiatives have been predominantly proposed for secondary grade levels, leaving elementary curriculum unchanged (Murphy & Mancini-Samuelson, 2012; Vasquez, 2005). STEM education in the elementary grades can cultivate students' confidence and positive self-efficacy in relation to their abilities to take part in advanced mathematics and science classes in the secondary grade levels (DeJarnette, 2012). Waugh (2000) recognized that teachers' receptivity might well be imperative to the success or failure of curriculum reform. Because teachers have such a deterministic bearing on the success of curriculum reform, this study sought elementary teachers' perspectives on integrated STEM education prior to formal approval and declaration of integrated STEM education implementation in elementary schools. This study is significant in that it provides valuable insight into elementary teachers' receptivity to integrated STEM education, differences among varied personal and school demographic subgroups, variables that have a relationship with teachers' receptivity, and teachers'

perspectives, insights, and concerns regarding implementation of integrated STEM education.

Significance for the researcher and the field of STEM research. This study provided the researcher with an opportunity to study elementary teachers' attitudes, behavioral intentions, perspectives, insights, and concerns toward integrated STEM education. This understanding provides an awareness for the researcher and others about selected personal and demographic factors that may influence teachers' receptivity to integrated STEM education, which can inform future studies, professional development efforts, and teacher education curriculum design to address any potential problems before likely implementation of integrated STEM education into the elementary grades. Finally, the findings of this study might aid the implementation of integrated STEM education into elementary schools.

Significance for the participants. This study may have provided the elementary teachers who participated in this study with awareness of national educational leanings toward the possible implementation of integrated STEM education in elementary schools to better prepare students as part of a wider effort to meet national workforce needs. Additionally, by choosing to participate, elementary teachers had the opportunity to voice their valuable perspectives, insights, concerns, and behavior intentions toward the implementation of integrated STEM education prior to formal approval and declaration of implementation. Thus, this research may aid in current and future teacher buy-in, which can ease transition of integrated STEM education into the elementary grades.

Significance for STEM educators. The study revealed elementary teachers' perspectives, insights, concerns, and behavior intentions toward the implementation of

integrated STEM education. Moreover, the study sought to pinpoint receptivity differences among demographic subgroups and variables that have a significant relationship with elementary teachers' receptivity (attitude and behavior intentions) toward implementing integrated STEM education. Findings may influence future instruction to address needs to overcome potential obstacles for implementing integrated STEM education into elementary schools for in-service and pre-service teachers. Finally, this research might provide a starting point from which to develop other studies involving elementary teachers and other stakeholders regarding the implementation of STEM education to augment and facilitate successful transition prior to formal approval and mandated implementation of it into the elementary grades.

Chapter Overviews

This section provides an overview of the next four chapters. Chapter two consists of an explanation of the human relations theory, which provides the theoretical framework for this study. The literature review that follows addresses integrated STEM education and its domestic value, U.S. students' performance in mathematics and science, federal funding for STEM programs and accountability, current STEM initiatives and programs, calls for STEM education in the elementary grades, and the importance of elementary teachers' receptivity to integrated STEM education for potential future implementation. Chapter three details the methods used for this study, including the research design, participant recruitment, instrumentation, and data collection and analysis. Further, the researcher-adapted 35-item, 7-point Likert scale survey instrument used in this study is provided. Chapter four presents the results of quantitative and qualitative analysis of data retrieved from surveys and eight follow-up interviews.

Chapter five discusses the findings related to the research questions posed. Implications for the potential implementation of integrated STEM education into the elementary school ensues, followed by an acknowledgement of this study's limitations. Finally, the merits of this research are addressed.

Chapter Two

Literature Review

This review of literature synthesizes information about integrated STEM education and its value in the United States education system, particularly in grade levels K-6. It begins with a discussion of human relations theory as a theoretical framework for this study. Next, STEM education is defined, followed by an argument for its significance in the field of education. In the next sections, U.S. students' mathematics and science achievements are presented and compared with students from other participating Organization for Economic Co-operation and Development (OECD) countries. Then several notable STEM education programs and initiatives presently in place are described. Finally, a case is made to develop and implement integrated STEM education in the elementary grade levels while noting the important role of teachers in meeting that goal.

Human Relations Theory

Classical and Human Relations. During the late 1920's, human relations theory came into existence. This was a reaction to counter the established classical organizational theory, which envisioned the workplace environment and employees as individual mechanical parts functioning to accomplish an output or goal. Classical organization theory takes the approach that workers are individuals separate from the authority, and under the guise of functionality and efficiency, workers are to absorb instructions and information from their superiors in a top-down authoritarian approach (Rose, 2005; Whyte, 1956). Different from the classical approach, Whyte (1956) describes the human relations approach as having established lines of communication that

flow from the top down and vice-versa. Further, human relations theorists recognized that workers are more than functioning robots; rather, they are people with social and psychological needs that can yield improved organizational efficiency and productivity if nurtured (AlMusaileem, 2012; Mayo, 1933; Roethlisberger & Dickson, 1966).

Humanistic needs and productivity. Researchers have studied the influence of meeting humanistic needs of employees on overall productivity (Mayo, 1933; McGregor, 1960; Roethlisberger & Dickson, 1966). Mayo (1933) focused his attention on the effects of worker conditions and production levels. Several important findings emerged, which are recognized as the Hawthorne Effect. Findings identified as the Hawthorne Effect include increased productivity by workers due to improved interest and concern displayed by managers during genuine and friendly face-to-face interactions. Further, Mayo found that informal groups formed among the workers and these groups were as influential as formal authority at establishing and maintaining working norms. Finally, it was determined that production improved when workers were given more freedom to make decisions concerning their working environments. Mayo acknowledged that this might have been a result of workers' need to feel valued, secure, and part of a cooperative working team.

Meeting humanistic needs. Analyzing the human factor within organizations, Roethlisberger and Dickson (1966) highlighted several areas to address to meet the inherent humanistic needs of workers. For the individual, better economic incentives and physical working environments are important, but nurturing workers' affective needs tend to be more effective for gross output. One way to meet emotional needs is by recognizing that workers add value to the organization and have expertise and insight that

may improve the overall working conditions and productivity of the workplace. Another way to meet the needs of the individual is recognizing that work is often a group activity; working in harmony, two is better than one when it comes to efficient output. Workers need to feel that they are part of a community working together for a greater goal.

Informal groups are self-formed groups within a recognized organization; they tend to occur at every level within the organization. These groups are often necessary to meet intrinsic needs of workers to see themselves not only as isolated entities, but also as equally important cooperative components of a larger organizational whole. They are often a response to individuals seeking to fit in with other workers that accept and value them as productive members of the group and organization (McGregor, 1960; Roethlisberger & Dickson, 1966).

Collaboration and collective buy in. Finally, there appears to be a need for workers to participate in organizational decision-making processes that influence policy changes that directly affect their working environments. Participants in this process may include informal group leaders chosen by their colleagues to represent a collective voice when providing input for solving problems or implementing shared change. Further, informal leaders can assist in providing productive face-to-face interaction, keeping workers engaged and informed regarding events and actions in the workplace, and maintaining lines of communication up and down the chain of command. A human relations organizational working model assumes that workers have perspectives and expertise that add to discussion and decision-making within the workplace. Consequently, workers may feel they are a part of something larger than themselves and that they contribute to the benefit of the greater whole, which can lead to cooperative

ownership and functioning toward meeting organizational goals (Roethlisberger & Dickson, 1966).

A Democratic Approach to Leadership in Education

Human relations theory has influenced how managers and supervisors are trained. The theory has helped to show how to increase productivity through improving group dynamics. A focus is placed on effective group collaboration, communication, and collective goal buy-in and pursuit (AlMusaileem, 2012). Not unlike other organizations, there is a need to meet the humanistic needs of workers within an educational setting to increase productivity and efficiency. Bureaucratic top-down approaches in education can strangle creativity, suppress valuable perspectives, and inhibit cooperative interaction in the name of order and structure. Some suggest that this style of administration is outdated and ineffective to meet the rapidly changing educational standards, strategies, and curriculum necessary to prepare students with the skills to compete in the 21st-century global market place (Gulcan, 2011; Mulkeen, Cambron-McCabe, & Anderson, 1994).

However, a democratic leadership approach utilizes the valuable human resources possessed within the school walls to assist in organizational decision-making. Change requires the combined efforts of all educators with a shared commitment to improve education. Elementary and secondary teachers, school counselors, and school and district administrators are valuable participants in decision-making processes regarding issues and reform relevant to the classroom, school, and district levels (Gulcan, 2011; Mulkeen, Cambron-McCabe, & Anderson, 1994).

What is Integrated STEM?

Views about the meaning of integrated STEM vary, even among those who possess significant interest in its development and implementation in K-16 education. Thus, because a consensus about what integrated STEM is has yet to be presented, it is difficult to state a definition that encompasses the myriad of perspectives on the concept with any sense of conviction. Breiner et al. (2012) found that even professionals in STEM and non-STEM fields at a university had a difficult time pinpointing what integrated STEM is. Even STEM professionals actively involved in STEM education and projects tend to perceive integrated STEM through their own specialty or discipline. As a result, no common perspective about what integrated STEM is has materialized. This confusion persists among those with vested interests in advocating for integrated STEM education, which has led to an awareness that merging STEM disciplines may be more difficult than once believed, and authentic integrated STEM education experiences may not be occurring as expected (Breiner et al., 2012; Brown et al., 2011).

However, various contributors have conceptualized and presented perspectives on what they think integrated STEM is, often filtering their understanding through their own occupational lenses (Breiner et al., 2012; Brown et al., 2011). Several perspectives come into view to provide insight into what various stakeholders understand integrated STEM education to be.

At the K-12 level, STEM content areas are often seen as separate entities taught within their own contexts. Therefore, with the push of integrated STEM education into K-12 grade levels, the most apparent change to teachers' understanding of STEM education is that the disciplines are to integrate across content borders and be taught

together using problem-based learning strategies and real-world problems (Breiner, 2012; Sanders, 2009). Merrill and Daugherty (2010) view integrated STEM education as an integration of science and mathematics content taught through engineering and technology lessons and units. Further, Merrill (2009) describes integrated STEM education as standards-based curriculum, particularly focused on integrating science, technology, engineering, and mathematics. Within Merrill's perspective, teachers of varying expertise must work together to strive to present lessons that allow integrated STEM content to naturally flow and merge.

Encompassing a much broader viewpoint, Tspuros, Kohler, and Hallinen (2009) relate to integrated STEM education from an international, competitive perspective. They state:

> STEM education is an interdisciplinary approach to learning where rigorous academic concepts are coupled with real world lessons where students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy (as cited in Lantz, 2009 p. 1)

Breiner et al. (2012) suggest that it may not be productive to focus on a definition of integrated STEM education due to the many perspectives people have concerning it. Rather, it may be more useful to focus collective energies on the goals of integrated STEM education. The main long-term goal of integrated STEM education is to produce a STEM-literate workforce, capable of pursuing available STEM jobs and producing

innovation that will yield economic advantages for the United States (Barakos, Lujan, & Strang, 2012; Breiner et al., 2012).

Why is Integrated STEM Education Important?

Global competitiveness. Many have warned that the United States risks losing its ability to be the world leader in the global marketplace (Barackos, Lujan, & Strang, 2012; Bybee & Fuchs, 2006; DeJarnette, 2012). The World Economic Forum (2012-2013) report evaluated 144 countries' competitiveness by assessing their national economic production and prosperity. The U.S. continues to decline in ranking; in fact, the U.S. has declined in ranking over the past four years, falling to seventh behind Switzerland, Singapore, Finland, Sweden, the Netherlands, and Germany. The problem is twofold. The U.S. is not preparing students with adequate STEM skills, nor with critical and creative thinking and communication and collaboration skills. Thus, the workforce is ill equipped to compete with other nations that are better preparing their citizens with these skills that are vital to adapt current and develop better technologies that are more efficient. To reverse this decline, most agree that innovation is crucial for the U.S. to maintain and improve international competitiveness (Business Roundtable, 2005; DeJarnette, 2012; National Science Board, 2007).

Many recognize competiveness as a nation's aptitude for producing leading and innovative technologies. Others suggest that competiveness defines a nation's ability to at the very least balance trade exports with imports. Others suggest that a definition of competiveness must include an economic ability to maintain working wages that preserve or improve citizens' standard of living (Ehrlich, 2007). If innovation is the answer, what does it mean for an economy to be innovative? According to Ehrlich (2007), innovation

is more than just invention; it is a process that incorporates several components. The parts include a functional education system that promotes thinking creatively, generating ideas, conceptualizing processes for the realization of those ideas, and recognizing skill sets workers will need to utilize the innovation. Park (2011) asserts that STEM fields are responsible, in part, for making life better by producing innovation that allows for more personal convenience and technologies that assist in extending peoples' life span. In a sense, innovation is power. A nation's ability to harness this power increases their ability to maintain or improve their global competitiveness. Moreover, Park (2011) posits that innovative capabilities are a distinguishing factor that separate developed from emergent economies.

Bybee and Fuchs (2006) contend that the U.S. finds itself in a position not unlike the race-to-space phenomenon that took place in the 1950s with the United States' urgent efforts to improve mathematics and science education in response to the Soviet Union's launching of its satellite Sputnik. The U.S. has been surprised once again by the ingenuity and innovation of other nations figuratively racing above and beyond former limits. This time, however, there are far more competitors than the former Soviet Union. Developed and developing countries alike are vying for a piece of the economic pie, fueled by technological creativity and development. It will take the same determination the U.S. displayed in the 1950s and 1960s to ensure that present educational programs provide curriculum appropriate to prepare students for the 21st-century workforce. Preparing the next generation with the skills necessary for competing with their international peers is imperative for maintaining the U.S's economic health (Bybee & Fuchs, 2006). The U.S. eventually won the race to space by landing on the moon 12 years after Sputnik was

launched. This was made possible, in part, by significant investment into developing education that emphasized mathematics and science. The same investment is needed today in integrated STEM education to produce innovation that will allow the U.S. to maintain its international competitiveness (Bybee & Fuchs, 2006; Dejarnette, 2012).

Stakeholders agree that if the U.S. is to preserve its global position as a leader and prevent future national economic decline, integrated STEM education will play an important role in this undertaking (Ehrlich, 2007; National Science Board, 2007; U.S. Department of Commerce, 2011). Three areas have been suggested as vital for transforming the current U.S. education system so that students are learning the STEM skills necessary to compete internationally. Teacher education programs must improve their curriculum to include quality STEM content and pedagogy. This might include courses heavily influenced by the thoughtful integration of STEM content presented through effective problem-based and inquiry-learning approaches. Pre-service teachers must be competent and confident with integrated STEM education if they are to be expected to help their students construct this knowledge for themselves. Next, teacher educators must reach out to K-12 educators. If change is to take place, novice and veteran administrators and teachers will have to learn appropriate STEM content and instructional strategies, and, just as important, develop a sense of urgency for implementing integrated STEM education in K-12 grade levels. Finally, administrators must encourage and support teachers' professional development so that students have frequent and quality integrated STEM educational experiences in school. To the degree possible, learning experiences should mirror those that professionals in the field routinely experience. Further, student learning should be developed through inquiry and problem-

based and project-based strategies so that students learn important cooperative, communication, problem-solving, and autonomy skills (DeJarnette, 2012).

Meeting job demands. Simply put, one goal of integrated STEM education is to build a workforce with the skills necessary to work in the STEM fields (Barakos, Lujan, & Strang, 2012; Merrill & Daugherty, 2010). According to the U.S. Department of Commerce's Economic and Statistics Administration (EPA, 2011), over the past decade, science and engineering jobs have rapidly increased at about three times the rate of other jobs. It is predicted that this growth will hold steady for some time to come. Many potential STEM professionals are dropping out of high school. Those that do graduate high school are not prepared to take entry-level courses in mathematics and science and thus may be leery about pursuing STEM degrees. In addition, a large percentage of potential STEM degree candidates drop out because of the rigorous academic nature of university programs. According to the U.S. Census (2010), less than 5% of all U.S. citizens with bachelor's degrees majored in any of the following STEM areas: computers, mathematics, statistics, or physical sciences. U.S. citizens with undergraduate degrees in engineering and biological science occupy a slightly higher percentage of the whole at about 7% each.

Percentages of engineering and science degrees held by foreign-born residents and U.S. citizens. Almost half of all foreign-born U.S. residents with bachelor's degrees or higher hold degrees in STEM fields (includes the aforementioned fields plus biological, agricultural, and social sciences) compared to 33% of U.S. citizens. In addition, although foreign-born residents make up only 16% of the population holding bachelor's degrees in the U.S., they possess 33% of all engineering degrees, one-quarter

of all computer, mathematics, statistics, and physical sciences degrees, and 17% of biological, environmental, and agricultural sciences degrees (U.S. Census, 2010). In the end, the U.S. is not producing enough qualified STEM workers to meet current employment opportunities within its borders (Ehrlich, 2007).

National shortage of native-born STEM professionals. Routinely, business leaders in the STEM fields have identified a shortage of potential employees with the necessary skill sets to be considered for entry-level positions (Business Roundtable, 2005; Park, 2011). Considering engineer production alone, Park (2011) asserts that the U.S. may need two more engineers for every one that is produced. Thus, foreign-born professionals fill many of these engineering jobs. For example, dramatic growth was predicted in the field of computer software engineering with an anticipated 368,000 positions over a ten-year span (2004-2014). With this growth and low production of computer software engineers in the U.S., reports indicate that 27% of the total computer engineer workforce is now comprised of foreign-born employees (Park, 2011).

The role of education in preparing STEM professionals. STEM education is critical for improving the numbers of competent STEM-trained workers in the present U.S. education system. If education initiatives encompass integrated STEM education, then, at the least, students will have experiences that expose them to STEM jobs and preparation for those jobs (DeJarnette, 2012; Murphy & Mancini-Samuelson, 2012; Russell, Hancock, & McCullough, 2007). Integrated STEM education provides exposure that allows students to be more informed before they make a decision whether or not to pursue a STEM degree in college (Murphy & Mancini-Samuelson, 2012; Walker, 2012).

Relationship of STEM dose to success in the STEM fields. Wai, Lubinski, Benbow, and Steiger (2010) conducted a longitudinal study that looked at the relationship of STEM dose (i.e., science and math fair, project development, AP course, and academic clubs) to STEM accomplishments (i.e., STEM occupation, graduate degree, publication, tenure, and patent). This study was conducted with three groups of 13-year-old students beginning in the late 1970s and early 1980s and continued over a 20-year span for each group. Findings showed that students with a higher STEM dose had more STEM accomplishments than their peers that were categorized as having a low STEM dose. For example, high-dose students were twice as likely to earn a STEM Ph.D., publish in the STEM fields, and make tenure, and they were more likely to work in STEM jobs and develop STEM patents.

21st-century skills. Barakos, Lujan, and Strang (2012) assert that the focal point of integrated STEM education is to prepare a STEM-literate populace that will use their skills and knowledge to solve problems that will ultimately better peoples' lives. One goal of integrated STEM education is to develop 21st-century skills necessary for job seekers to be employable in the rapidly evolving high-tech workforce (Bybee & Fuchs, 2006; Meyrick, 2011). Understanding what 21st-century skills are can be elusive. Opinions concerning what these specific skills entail differ, but most recognize that they are associated with complex thinking, learning, and communication skills (ITEA, 2000; Saavedra and Opfer, 2012). Meyrick (2011) asserts that strategies such as problem-based projects, inquiry learning, and student-centered learning offer some advantages to implementing integrated STEM education, and these strategies facilitate development of 21st-century skills. Wagner (2008) and Alozie, Grueber, and Dereski (2012) describe 21st-

century skills as survival skills; that is, skills that are central to success in the STEM fields. After interviewing hundreds of professionals concerning their perceptions of what employee skills are vital in the workplace, Wagner (2008) found that professionals most often designated the following: critical thinking, problem solving, collaboration, adaptability, effective oral and written skills, accessing information, and imagination.

Bybee (2009) sought to name essential 21st-century skills to help to alleviate the apparent confusion about what they are and how they apply to teaching science (i.e., what needs to be taught and learned). Bybee (2009) described five skills as examples vital for the current high-tech workforce: adaptability, complex communications and social skills, non-routine problem solving, self-management and development, and system thinking.

Adaptability is the ability to be flexible during problem solving and learning new technologies when confronted with unfamiliar and varying circumstances. Further, it is the skill of working with other people with varied communication styles and personalities (Bybee, 2009). Alozie, Grueber, and Dereski (2012) describe adaptability as an important skill for adjusting to challenges that will inevitably occur during real-world experiences and problem solving.

Complex communication and social skills refer to an ability to conceptualize information and articulate that knowledge in a way that might best promote understanding for other collaborators and/or contributors (Bybee, 2009). Understanding can be achieved through physical (images, modeling, graphics) and oral (listening, talking) forms of communication (Bybee, 2009; Levy & Murnane, 2004).

Non-routine problem solving requires possessing flexible strategies so that a starting point to attack a problem can be found (Bybee, 2009). London (2004) maintains

that solving non-routine problems involves recognizing the problem, trying something to overcome an obstacle, and persisting until an appropriate process is employed, which is similar to developing and possessing what Polya (1945) described as a problem-solving heuristic. Further, Bybee (2009) says that non-routine problem solvers need metacognitive skills, which involve an ability to self-monitor one's thinking throughout the process and recognize appropriate strategies and solutions.

Self-management requires a learner to be able to stay focused on and committed to resolving or finding solutions to problems. Often, motivation is the result of positive attitudes and dedication to pursuing answers to problems that are relevant and thus important to those who seek them (Bybee, 2009). Alozie, Grueber, and Dereski (2012) propose that self-management skills can develop over time so that learners improve self-motivation, potentially increasing productivity outside of cooperative work.

Systems thinking requires understanding an entire system, including all of its principle functional parts and their interactions that produce some outcome. In knowing these intricacies, troubleshooting can be efficient in the event that a malfunction occurs (Bybee, 2009). Alozie, Grueber, and Dereski (2012) state, "It is important that students understand the concepts of how systems work--how an action, change, or malfunction in one part of the system affects the rest of the system--and thereby adopt a 'big picture' perspective of their learning" (p. 488).

Personal and national prosperity. The state of the current U.S. economy can at best be described as stagnant. Over a three-decade span from 1978 to 2005, the median wage growth for citizens, after corrections for inflation were considered, increased by approximately $400 or about 2% for annual earnings for full-time work. It is said that

over that period of time, middle-income earners have lost about a generation of economic growth (Ehrlich, 2007). Since the year 2000, all levels of skilled workers designated by education attainment (i.e., less than high school, high school, some college, bachelor's degree, and advanced degree) have experienced decline in monetary annual earnings. The one exception is the top 1% of income earners; they have experienced substantial income increases over the same period of time (Haskel, Lawrence, Leamer, & Slaughter, 2012).

Denny (2011) asserts that the time has long passed since the U.S. could rely on its wealth of natural resources to maintain an economic advantage over the rest of the world. Today, there is no doubt that innovation will play a critical role in producing economic growth and thus the U.S's capabilities to maintain such an advantage in the future. The U.S. currently remains the leader in overall annual production in the world; however, the U.S. has not been able to compete with other countries in growing national annual production (Santiso, 2010). The services and outputs produced by workers in one country for one year has a total dollar value; this dollar value divided by the population reveals the standard of living or gross domestic product (GDP; Bevins, Carter, Jones, Moye, & Ritz, 2012). GDP for the U.S. and the world overall has grown in the past two decades. Although the United States' GDP has grown annually at an average of 2.7% from 1990 to 2008, the world's annual average growth at 3.4% has outpaced the U.S's. growth by almost 1% per year. China's 9.9% and India's 6.3% annual GDP growth far exceeds the U.S's and the rest of the world's economic growth over the past two decades (Haskel et al., 2012). China's and India's success is attributed to their greater international competiveness, particularly, their ability to produce improved technology

and innovation. Improved technology and innovation can be attributed, in part, to a labor force capable of producing it (Bevins et al., 2012).

Economic growth is a nation's ability to produce more output. Economic growth depends on an ability to determine ways to be more efficient with current productions and the ability to develop new technologies that will expand and diversify production; this is recognized as innovation. Innovation and thus economic growth can be attained by finding ways to get more out of resources, improving methods of production along assembly lines, and enhancing distribution capabilities (Bevins et al., 2012; Ehrlich, 2007). Consequently, innovation raises annual production and increases overall national output value, which in turn improves national prosperity (Ehrlich, 2007).

The United States has benefited in the past by preserving an economic advantage over much of the world because of engineering and science initiatives. However, this advantage is declining. Other countries are in quick pursuit to catch and surpass the U.S. in providing the world with STEM-oriented innovation. The ability to produce innovation is more crucial today than in times past to stay internationally competitive (Bevins et al., 2012). The focus on and development of STEM skills is paramount for U.S. citizens in the 21st century in order to continue national advancement and maintain international leadership in innovation (National Science Board, 2007). Barakos, Lujan, and Strang (2012) assert that the focal point of integrated STEM education is to prepare a STEM-literate populace that will use the skills obtained therein and their knowledge of their surrounding environment to solve problems that will ultimately better their lives.

Innovation is one way to maintain global economic standing and national prosperity in the U.S. Integrated STEM education is acknowledged as a tactic to produce

the next generation of scientists, engineers, and mathematicians to maintain national leadership in scientific discovery. Future STEM professionals will continue to reinvent and create new technology that will ultimately generate better-paying jobs to produce, maintain, and use it (Ehrlich, 2007). Highly skilled professionals are responsible for creating innovation that will ultimately produce more jobs. Integrated STEM education is beneficial two-fold. It prepares the next generations with the high-tech skill set they need to fill the jobs currently left unfilled by U.S. citizens, and, ultimately, those workers produce innovation that will require skilled labor to develop, manufacture, and use it (Ehrlich, 2007; ITEA, 2009; Lantz, 2009).

Status of U.S. Students' Performance in Mathematics and Science

The National Assessment of Educational Progress (NAEP) assesses U.S. students' achievement in reading and mathematics. NAEP 2005, 2007, 2009, and 2011, published by the U.S. Department of Education, results will provide the backdrop for explaining how U.S. students performed in mathematics in the recent past based on achievement scores on the Long-Term Trend (LTT) NAEP and the Main NAEP, primarily the latter. The LTT assessment, unchanged since its creation, is typically used to show ascending and descending trends in students' performance, while the Main NAEP assessment has been modified over time to include innovative standards perceived essential for evolving mathematics skill development. Finally, NAEP compares fourth, eighth and twelfth graders (Main) and 9, 13, and 17 year-olds (LTT; Rutledge, Kloosterman, & Kenney, 2009).

NAEP 2009 and 2011 categorized students into less than basic, basic, proficient, and advanced levels based on their mathematics performances. *Basic* considers students

as knowing only some of the fundamental skills; *proficient* describes students as being competent overall; finally, *advanced* indicates superior performance. The NAEP, 2009 reported that 39% of fourth graders tested nationally were proficient or above. In 2011, the results were similar for fourth graders with 40% reaching proficient or above. Although there was a slight improvement, still 60% of fourth graders were less than proficient and 18% of those performed at less than basic in 2011. On the opposite end of the continuum, 6% of fourth graders in 2009 and 7% in 2011 scored at the highest level in mathematics (advanced; NCES, 2011).

NAEP 2009 and 2011 data showed that 34% of eighth graders were proficient in 2009, with only a slight increase in 2011 to 35%. More than one in four eighth-grade students showed that they lacked even basic mathematics mastery, scoring below basic in 2009 and 2011. Eight percent of eighth graders distinguished themselves as advanced in 2009 and 2011; however, that growth flat-lined over those two years.

The NAEP mathematics assessment was not administered in 2007 or 2011 to twelfth graders, so scores from NAEP, 2005 and 2009 assessments are utilized to describe U.S. twelfth-grade students' mathematics achievement. NAEP 2005 showed that 23% of twelfth graders were proficient or above. However, three percent growth was made on the NAEP 2009 assessment four years later, improving the percentage of twelfth graders proficient or above in mathematics to 26%. The number of U.S. twelfth graders scoring at an advanced level in mathematics proficiency in 2005 was 2%, with an increase of 1% in 2009 to 3% (NCES, 2009).

Overall, in 2011, NAEP data showed that the percentage of fourth and eighth graders scoring proficient has moderately improved; the past decade alone (2000-2011)

has shown that 16% more fourth graders and 11% more eighth graders scored proficient or above during that time period. In spite of this, between 2007 and 2011 (2005 and 2009 for twelfth graders) overall progress has slowed to a crawl, with 1% more fourth, 3% more eighth, and 1% more twelfth grade students achieving proficient or above scores in mathematics. Moderate overall progress has primarily come from the middle; the highest and lowest achievers have made little to no overall progress. Growth in the number of students attaining the highest level (advanced) and the number of students moving up from below basic has been relatively inert for some time at all three grade levels.

International comparisons: Trends in International Mathematics and Science Study (TIMSS) provides international comparisons of fourth and eighth graders' mathematics and science achievement comparisons. TIMSS 2007 reported that U.S. fourth and eighth graders on average scored above 500 in mathematics and science, which was set as the TIMSS scale average. Mathematics scores showed that U.S. fourth graders scored on average 529 points and eighth graders scored an average of 508. U.S. fourth graders ranked 11th of 35 participating countries and Hong Kong (36 participants total), performing above 25 and below 10. U.S. eighth graders ranked ninth among 48 participating countries (including Hong Kong; NCES, 2009)

In science, U.S. fourth and eighth graders scored above the TIMSS scale average of 500 as well. On average fourth graders scored 544 and eighth graders scored 525. U.S. fourth graders, compared among 57 participating countries, ranked below six other countries in science, tied with three, and placed above 47 other countries. Science scores for U.S. fourth graders have remained unchanged since 1995, with only a two-point overall change since then. In addition, 15% of U.S. fourth graders in 2011 scored at an

advanced level (≥ 625) on the science assessment. U.S. eighth graders' science achievement, compared among 56 participating countries, ranked below 12 countries, tied with ten, and placed above 33 others. However, between 1995 and 2011, U.S. eighth graders' science achievement improved by 12 points, which is measurably significant over that 16-year span, but is not statistically different from scores on the previous TIMSS assessment conducted in 2007. Ten percent of U.S. eighth graders scored at an advanced level on the TIMSS science assessment (NCES, 2011).

Schmidt (2012) acknowledged that the mathematics results painted U.S. fourth and eighth graders' abilities compared to their international peers more positively than ever before, but proposed this may have more to do with other countries choosing not to participate than with U.S. achievement gains. Schmidt recognized that countries that have routinely outperformed the U.S. in the past did not participate in the TIMSS 2007 study (e.g., Belgium, Canada, France, and Switzerland). In addition, several countries only participated in either fourth or eighth grade (fourth only: Austria, Denmark, Germany, New Zealand, and Netherlands; eighth only: South Korea). Evidence of subtle gains are in the numbers with only moderate overall gains on the TIMSS between 1995 and 2007 by U.S. students (fourth grade = 11-point growth; eighth graders = 16-point growth).

Programme for International Student Assessment (PISA) is administered by the Organization for Economic Co-operation and Development (OECD). It presents mathematics and science literacy comparisons of 15-year-old students (ninth/tenth graders). The PISA differs from the TIMSS and NAEP in that it monitors and compares mathematics and science literacy skills in addition to content knowledge. Specifically, the PISA focuses on how well adolescents (15-year-olds) can apply mathematics and science

knowledge to their personal experiences and the environment beyond the classroom. Further, thinking, reasoning, and overall authentic problem-solving skills (i.e., reproduction, connection, and reflection) are skills necessary to be successful on the mathematics assessment. The science literacy portion requires the learner to identify, apply, and reflect on their understanding of science and technology to solve challenging, authentic problems (OECD, 2007; Schmidt, 2012).

In 2003, PISA results showed that U.S. students averaged 472 points, which was below the OECD mean of 486 points, ranking U.S. students 24th of 41 participating countries. A comparison for problem-solving aptitude showed that U.S. students' average scores were significantly below the OECD mean, ranking them within a range of 26-30 among all participating countries. Note that a range of rankings was assigned due to data coming from population samples; thus, it was not considered possible to get exact rankings. However, PISA determined a 95% likelihood that a country's problem-solving mean score ranking fell within the designated ranges (OECD, 2003).

PISA results showed some improvement in average mathematics literacy scores, up from 472 points in 2003 to 487 points in 2009. However, the average score of 487 for U.S. students still fell significantly below the OECD mean of 496. Further, a greater percentage of U.S. students (but not significantly greater) were categorized as low performers based on their achievement scores compared to the OECD average of 22%. The number of U.S. students identified as high performers remained stable between 2003 and 2009 at 10%, showing that there were significantly fewer U.S. high achievers compared to the 13% average number of high achievers in OECD participating countries.

However, the gap has closed due to an average international decline of two percent from 2003-2009.

For science literacy, PISA uses six proficiency-level categories ascending in numerical order with six recognized as the highest attainment level. U.S. fifteen-year-olds scored on average 502 points, one point higher than the OECD average of 501, but not significantly different. This is a 13-point improvement by U.S. students, up from the 489 average attained on the PISA 2006, elevating students from below the OECD international average in 2006 to on par with it in 2009. U.S. students ranked below 12 other nations, were comparable to 12 others, and ranked above nine nations. Although progress has been made, there is still cause for concern for a large percentage of U.S. students that lack basic scientific literacy skills. The results show that the percentages of U.S. students in each of the six levels and below level one are: (below level 1 = 4%, level 1 = 14%, level 2 = 25%, level 3 = 28%, level 4 = 20%, level 5 = 8%, and level 6 = 1%). Twenty-nine percent of U.S. students scored at level four or above, which is described as an ability to use higher-order thinking skills to choose and bring together ideas from varied disciplines in science or technology to understand life and the world. Further, 18% of U.S. students scored at level one or below, identified as a lack of skill acquisition necessary to function in situations requiring scientific and technological inquiry. The remaining 53 percent achieved at level two or three, described as adequate scientific knowledge but lacking the higher-order thinking skills to integrate multiple disciplines and make connections to their environments.

Addressing STEM Education in the United States

Federal funding for STEM education. In response to continual U.S. students' general poor performance in mathematics and science on the NAEP, PISA, and TIMSS assessments, President Obama has emphasized a plan to "educate to innovate." This plan calls for integrated STEM education to take priority, which has generated an explosion of funding to move the STEM education initiative forward (Obama, 2009). In part, states were required to compete for some of that funding by creating and implementing STEM initiatives, some of which included developing STEM networks, state-wide regional STEM facilities, K-12 programs and curriculum, STEM high schools, and professional development opportunities for teachers (Johnson, 2012).

President Obama (2009) committed over four billion "Race to the Top" dollars to STEM programs that would ultimately nurture and improve public literacy in mathematics and the sciences and to prepare citizens to fill STEM workforce needs. More recently, President Obama (2013) committed 3.1 billion dollars for STEM programs for the 2014 fiscal year. This money will go to 112 government-supported STEM programs. Of the 3.1 billion dollars, $814 million targets K-12 education. $150 million of this is designated for improving relationships between school districts and universities to build partnerships. For continued pursuit of the President's goal of preparing 100,000 STEM-trained teachers, $80 million is allocated, and $35 million is authorized for starting a master teacher program where the best science and mathematics teachers are recruited to help improve instruction in their schools and districts. The remaining funds (over $400 million) will go to redesigning high schools to make them

STEM-focused and to research dedicated to improving the teaching and learning of integrated STEM education.

STEM Education Funding Accountability

Federal Accountability. The U.S. Government Accountability Office study (GAO, 2005) found that of the $2.8 billion spent during the 2004 fiscal year on STEM programs, the vast majority ($2 billion) went to the National Institute of Health and the National Science Foundation. Further, $221 million went to the Department of Education, which was $10 million less than what went to NASA. The primary goal of these federally funded STEM programs was to improve the number of college graduates pursuing STEM graduate degrees and post-doctoral employment in STEM fields. However, preparing K-12 teachers in STEM education was identified as the lowest priority among the educational goals. In addition, the GAO (2005) found that 11 groups were targeted by the federally funded programs (e.g., middle school students, junior college students, graduate students, college faculty). The lowest-priority group among the federally funded STEM programs was elementary school students, followed by middle school students.

Academic Competitive Council. Similar findings were determined by the Academic Competitive Council (ACC; 2007) for the 2006 fiscal year. The U.S. federal government committed approximately $3 billion to fund STEM programs in 2006. The top two benefactors of that money were the NSF followed by the NIH. However, funding for the Department of Education did more than triple to $706 million since the 2004 budget. Like the GAO, the ACC (2007) found that graduate and postdoctoral support was the overarching goal of many of the STEM programs, accounting for almost half of the $3 billion 2006 budget. In addition, about $1 billion more went to improve undergraduate

STEM programs, leaving just over 20% of the budget dedicated to developing K-12 STEM education and outreach programs. The ACC (2007) looked at the effectiveness of the federally supported programs through evidence provided by internal evaluations conducted by many of the STEM programs. Of the 115 internal program evaluations investigated by the ACC, 10 were considered scientifically rigorous enough to be used to evaluate STEM programs. Of those studies, three concluded that the STEM programs had a significant impact on their target goals or groups, whereas seven others concluded less positive results.

STEM Goals and Key Approaches for Addressing Them

Varying opinions abound concerning how to best promote integrated STEM education to create a STEM-literate populace. For example, what strategic areas should take priority for funding? Most agree that one key goal of STEM initiatives is to train teachers to prepare students with the skills they need to pursue and work in the STEM fields. In doing so, the next generations will be better prepared to compete in the global marketplace, leading to maintaining or improving domestic economic advantages (Breiner et al., 2012). Addressing this issue from an elementary school perspective, DeJarnette (2012) suggests that one way to address STEM literacy issues is to improve working relationships between higher education and elementary education to shift pedagogical practices to allow more student inquiry and problem-based learning. Others suggest that STEM professionals working in the field should be included in this collaboration (Kuenzi, 2008; Kuenzi, Matthews, & Mangan, 2006; National Science Board, 2007). One way to address this is for university professors to share their expertise and research findings with educators during professional development. In addition,

providing quality integrated STEM out-of-school programs, such as summer camps, classes, and workshops for younger students, can help provide authentic experiences that will ultimately improve 21st-skills necessary for STEM occupations.

Similarly, Barakos, Lujan, and Strang (2012) propose three objectives of STEM programs for producing a "STEM-literate" and "savvy workforce." The word "literate" is the key in the phrase STEM-literate, which is another way of saying that pedagogical practices should be addressed to improve students' 21st-century skills through inquiry-based learning. The second objective is to develop STEM training programs that prepare students in areas that are specific to workforce needs (e.g., computer and mechanical engineers). The third objective is to develop STEM programs or schools fully dedicated to and focused on providing integrated STEM education. The Carnegie Foundation's (2009) report describes similar goals to address the domestic STEM literacy issues and professional shortages in the U.S. with one exception. They call for fewer overall but more rigorous mathematics and science standards and assessments that align with those standards.

Curricular standards. Although there are no designated STEM standards, much has been done to improve curricular standards in various STEM content areas. Since 2010, 46 states have voluntarily accepted and many have fully adopted the Common Core State Standards (CCSS). Educators and administrators came together from 48 states and several U.S. territories to select and build upon previously classroom-tested national and international standards to create English language arts and mathematics CCSS for the K-12 grade levels (NGA, 2010). CCSS mathematics standards are demanding, incorporate real-world problems, and seek to focus students' attention on why they are doing

mathematics over how to do it. Further, the CCSS are intended to bridge gaps among students by providing academic guidelines to all educators, in all grade levels, in all states and territories to ensure college readiness (Robison, 2012; Russell, 2012). Prior to the development of the Next Generation Science Standards (NGSS), state science standards were adopted and/or adapted from the National Science Education Standards developed by the National Research Council (NRC, 1996) or the Benchmarks for Science Literacy developed by the American Association for the Advancement of Science (AAAS, 1993). In April 2013, the NRC released NGSS. These standards cover grades preK-20 and are said to differ from any science standards used before. NGSS (2013) focus attention on processes; that is, more emphasis is placed on how to reach understanding in science than on the conclusions themselves. Further, these standards incorporate big themes and ideas that require grasp of the multiple STEM content areas, their interactions, and major ideas that crosscut the disciplines (e.g., cause and effect, patterns, and systems). Finally, not unlike the NRC (1996) standards, NGSS promotes inquiry learning, allowing for more student-centered learning through self and cooperative ingenuity and creativity.

Examples of Notable STEM Programs

Curriculum developers. To address quality pedagogical practice through curriculum development, Project Lead the Way (PLTW) and Engineering is Elementary (EiE), along with other innovators, have stepped up to try to fill the demand for STEM-educated individuals. Both are programs dedicated to developing integrated STEM curriculum with an emphasis on engineering and science that promotes hands-on, project-based learning opportunities. Engineering is Elementary, due to its elementary-grade-level focus, incorporates literacy and social studies to inform students about STEM

occupational settings and professionals (Brenner, 2009; Lottero-Perdue, Lovelidge, & Bowling, 2010).

Integrated STEM high schools. North Carolina was one of the recipients of Obama's (2009) Race to the Top funding. In part, this due to having in place highly effective STEM-integrated high schools. North Carolina School of Science and Mathematics (NCSSM) provides high school juniors and seniors with rigorous STEM courses and opportunities to participate in research and mentoring programs, which the majority do because of the 2,200 hours of service they are required to perform. The NCSSM has been very successful, with 99% of their student body entering college after graduation (Barakos, Lujan, & Strang, 2012; Park, 2011). Other notable STEM high school programs are Thomas Jefferson High School of Science and Technology in Virginia, Illinois Mathematics and Science Academy, and Brooklyn Technical High School in New York (Park, 2011). In addition, Energy Projects in Community Service Learning (EPICS) incorporate STEM education into 32 high schools across the nation. A small, diverse population (65 students mixed by gender, social class, and ethnicity/race) receives integrated STEM education. They participate in student-centered, project-based learning where research and collaboration with the business communities is an integral part of the curriculum (Kelley & Pieper, 2009).

Teacher education programs. Many universities have directed their attention to producing STEM teachers. This task is challenging considering it is difficult to get STEM graduates to settle for lower-paying education jobs in place of better-paying STEM jobs. The University of Texas has developed UTeach to combat the shortage of mathematics and science teachers. STEM faculty and education professors and experienced

mathematics and science teachers worked together to develop the program to recruit mathematics and science undergraduates into the field of teaching. STEM courses, often taught by STEM professors, include best pedagogical practices. Often, the practicums are run by master mathematics and science teachers that guide undergraduates through practicum experiences as early as their first year. To recruit mathematics and science majors, many classes are free. In 2007, funding from ExxonMobil and the U.S. Department of Education was committed to duplicate UTeach in other universities around the nation, such as Florida State, Louisiana State Baton Rouge, Northern Arizona, University of California (Berkeley and Irvine), Temple, Florida, Houston, Kansas, Texas Dallas, and Western Kentucky (Brainard, 2007; Cavanagh, 2007).

STEM collaboration. Over half of the funding for STEM programs in 2004 by the U.S. Department of Education went to the Mathematics and Science Partnership program (MSP). The funding was intended to build working relationships between university and college STEM faculty and high-needs schools to improve pedagogical practices and content knowledge of mathematics and science teachers. Black Hills State University was one recipient of this funding. University STEM and education faculty worked with K-12 teachers in Rapid City School District to boost overall achievement, reduce mathematics and science achievement differences between Native American and non-Native American students, retain good mathematics teachers, and improve the number of students taking high school college prep mathematics courses (Kuenzi, Mathews, & Mangan, 2006).

Two notable statewide collaborations are Missouri Mathematics and Science Coalition (METS) and the Ohio STEM Learning Network (OSLN). Both embrace

collaboration among educators, business, government, community, and philanthropic leaders to improve STEM education in their state. Cooperative problem solving among these stakeholders includes reviewing and developing curriculum, improving professional development, improving dispositions of students toward STEM subjects and occupations, creating and maintaining STEM hubs (out-of-school centers), and providing monetary incentive to recruit and retain the best STEM teachers to effectively reach states' STEM goals. Some of the STEM goals include: (a) improve student achievement (b) increase the number of students pursuing STEM degrees (c) increase the number of STEM-trained teachers (d) promote awareness and support and (e) improve the number of STEM advanced degree graduates (Barakos, Lujan, & Strang, 2012).

STEM Education in K-12

To date, integrated STEM education in not well understood. Although much is being done to improve STEM education, no implicit definition exists (Brown et. al., 2011). Even STEM faculty active in the fields of study do not have a common vision of integrated STEM education (Breiner et al., 2012). In addition, Brown et al. (2011) found that the majority of high school administrators interviewed could not provide even a description of STEM education, let alone articulate an understanding of it. Moreover, most high school teachers and administrators declared STEM education as vitally important for their students and schools, but lacked a unified plan on how to make use of it and determine who should receive it. Lantz (2009) asserts that the arm of STEM education has yet to stretch out and reach K-12 grade levels. Yes, some (very few) have experienced reform, but the vast majority have yet to experience innovative curriculum, STEM programs, or STEM schools. Further, Lantz (2009) asserts that high schools tend

to maintain status quo with mathematics and science subjects compartmentalized and teachers remaining isolated by the content they teach. Elementary and middle school teachers often lack the training to be highly qualified to teach integrated STEM education; thus, little has changed at lower grade levels as well.

STEM education: high school focus. Overwhelmingly, K-12 STEM initiatives for U.S. schools are directed at high school grade levels (DeJarnette, 2012; Murphy & Mancini-Samuelson, 2012). Much of the K-12 STEM program budget is directed toward creating STEM integrated high schools (ACC, 2007; GAO, 2005). A major factor for states competing for Obama's (2009) Race to the Top funding was reforming existing high schools that were STEM focused. Further, much of the STEM education curriculum is currently produced and marketed for high school grade levels (Brenner, 2009; Lottero-Perdue, Lovelidge, & Bowling, 2010). Although most agree that secondary STEM initiatives are essential, some suggest that by narrowing the focus to secondary grade levels we may be overlooking the benefits of early exposure to STEM education in the elementary grade levels (Russell, Hancock, & McCullough, 2007).

STEM education: elementary schools. STEM education initiatives are rarely designed solely for elementary grade levels (DeJarnette, 2012). ACC (2007) and GAO (2005) accountability reports both showed that K-12 grades are the least targeted groups for federal funding with elementary students targeted far less than middle and high school students. Some evidence suggests that STEM education is making its way toward elementary schools, migrating down from secondary STEM curriculum and programs (Hathcock et al., 2012). Considering the national landscape, integrated STEM education has yet to reach the vast majority of K-12 students in the United States. Many call for

integrated STEM education initiatives that are intentionally directed at elementary grade levels. They argue that early exposure to integrated STEM education is the best time to make a positive influence on more impressionable younger students. This may be done by providing grade-level-appropriate, integrated STEM education with real-world class experiences that mirror future employment tasks and provide elementary students with a genuine understanding of what STEM professionals do in their occupations (DeJarnette, 2012; Murphy & Mancini-Samuelson, 2012; Walker et al., 2012).

Elementary students are not too young to participate in and understand STEM education concepts (Brenner, 2009; Bybee & Fuchs, 2006; Walker et. al., 2012). DeJarnette (2012) asserts that elementary students possess the ability to participate in integrated STEM education that incorporates student-directed problem solving. Further, integrated STEM education positively affects elementary students' self-confidence and self-efficacy related to future STEM lessons and classes. Lottero-Perdue, Lovelidge, and Bowling (2010) found that integrated STEM education utilizing hands-on and inquiry-based strategies improved students' self-management skills (i.e., autonomy). Exposure to integrated STEM education in the elementary grades may spur students' interest in STEM and thus enthusiasm to take higher-level mathematics and science courses in secondary school to prepare for pursuing STEM degrees in college and careers. Early experience can eliminate unintentional ignorance students may have due to not having opportunities to experience integrated STEM education, which can affect their career paths (Russell, Hancock, & McCullough 2007).

Meeting STEM Goals and Teachers' Receptivity

Few would disagree that K-12 STEM education initiatives and programs are key for preparing citizens for STEM jobs that will ultimately be responsible for producing innovation, which will help, in part, to maintain the United States' ability to remain a global leader (Bybee & Fuchs, 2006; National Research Council, 2007). Implementing quality STEM initiatives and programs will not be easy. It will take the combined effort and support of all stakeholders to meet the national STEM goals in the United States (National Science Board, 2007). It is no surprise that teachers will play a significant role in this process. In fact, research has shown that teachers' receptivity to educational reform is a strong indicator for influencing successful or unsuccessful outcomes (Waugh, 2000; Yin & Lee, 2008). Empowering teachers by giving them a voice in the decision processes concerning changes that directly affect them, their students, classrooms, and school environments may go a long way toward improving their receptivity to reform (Lee, Yin, Zhang, & Jin, 2011; Waugh & Godfrey, 1993, 1995).

As with any major educational reform, students and teachers will often be the most influenced by curriculum change; therefore, their receptivity will greatly determine the success or failure of its implementation (Ha, Wong, Sum, Chan, 2008; Lee et al., 2011; Waugh, 2000). Teachers' partnerships, collaboration, insight, and perceptions are important for productive school environments, especially during times of reform. When policy makers and administrators see all contributors as valuable parts of a collective whole, a school culture of cohesive leadership and responsibility can ensue to best suit all parties affected by the change. Providing opportunities for teachers to share their expertise, ideas, and perspectives on how best to implement and improve the new

curriculum with sincere consideration to hear and potentially incorporate feedback by chief decision makers can ease transition and augment success (Collins & Waugh, 1998).

One of the major national goals that U.S. stakeholders agree upon for STEM education to address is to improve teacher education programs and teacher professional development training to prepare teachers to be highly qualified to teach integrated STEM education. The present study reveals elementary teachers' attitudes, concerns, perceptions, thoughts, behavioral intentions toward, and recommendations for implementation of integrated STEM education. Moreover, the study sought to pinpoint personal and demographic factors that have a significant relationship with elementary teachers' receptivity. Finally, the study compared various demographic groups to see if their responses significantly differed. Findings highlight comparisons of target groups and variables that have positive or negative relationships with teachers' receptivity. This knowledge, at the very least, can influence future STEM education training and course development in efforts to positively influence teachers' receptivity. In doing so, many unforeseen obstacles may be addressed before potential STEM education reform initiatives are mandated in elementary schools. Finally, the researcher hopes that this study will provide a starting point from which to develop other studies that initiate discourse with elementary educators and other stakeholders regarding their perspectives on integrated STEM education prior to formal approval and mandated implementation in order to learn more about how to implement this reform successfully and efficiently.

Chapter Three

Research Design and Method

Overview

In chapter two, literature related to integrated STEM education in general and particularly in grade levels K-6 was examined and presented. Human relations theory was discussed as the study's theoretical framework. Next, integrated STEM education was defined, and an argument was made for its inclusion in grade levels K-16 for preparing the present and future domestic workforce to compete with increasingly skilled competitors from around the world. In addition, U.S. students' achievement in mathematics and science according to national (NAEP) and international (TIMSS, PISA) standardized tests was presented. An overview of federal funding for STEM programs and allocation of that funding followed. After that, the current neglect of integrated STEM education in the elementary grades was underscored. Current and popular STEM initiatives were described, and a case was made for the significant need for integrated STEM education in the elementary grades. Chapter Two ended by noting the importance of teachers' receptivity to implementation of integrated STEM education.

The survey for this study was adapted from Waugh and Godfrey's (1993, 1995) and Lee's (2000) receptivity to change survey instruments. The survey was pilot tested with three teachers with credentials and experience similar to that of the targeted research participants. After revisions were made, 181 participants opted to complete the survey online, and data were analyzed quantitatively. Following the survey closing date, eight interviews were conducted with volunteers who had also participated in the survey. It was planned to purposefully select interview participants from three paired subgroups because

of the large numbers in each subgroup and the significant receptivity differences found between two of the three-paired subgroups. Because eight teachers volunteered for an interview, no preference was given to participants that fell into established demographic categories, specifically, grade level assignment (primary or intermediate), school teaching experience (novice or veteran), and school Title I eligibility or ineligibility. However, the eight participants were evenly split according to teaching assignment and teaching experience (4 = primary and 4 = intermediate; 4 = novice and 4 = veteran). Conversely, all eight participants interviewed worked at Title 1 eligible schools. In addition, three interview participants worked at two STAR performance rated and five worked at three STAR performance rated schools. The remainder of this chapter includes the research design, description of the participants and instrument, and procedures used for participant recruitment, data gathering, and data analysis.

The purpose of this study is to investigate elementary teachers' receptivity to integrated STEM education prior to formal approval and declaration of its implementation in elementary schools. Further, this study examined the relationships, if any, between elementary teachers' receptivity to STEM education and their concerns associated with implementing STEM education in the elementary grades, perceived school and other types of support, perceived practicality of implementing integrated STEM education in the elementary grades, and certified teaching experience. Finally, this study explored the differences, if any, in elementary teachers' receptivity among subgroups formed by demographic data (i.e., assigned grade level, primary or intermediate; years of certified school teaching experience, novice or veteran; school

Title I eligibility, eligible or non-eligible; and school STAR performance rating, 1-2, 3, or 4-5 STARS).

The research questions for this study are:

1. What is elementary teachers' degree of receptivity to implementing integrated STEM education in the elementary grades?

2. What differences, if any, exist among selected elementary teacher subgroups in receptivity to implementing integrated STEM education in the elementary grades?

3. What relationships, if any, exist between elementary teachers' receptivity to and potential concerns associated with implementing integrated STEM education in the elementary grades and their perceived school and other types of support, perceived practicality of implementing integrated STEM education in the elementary grades, and teaching experience?

4. What are elementary teachers' perceptions toward the possible implementation of integrated STEM education in the elementary grade?

Design of the Study

Mixed-methods research is an increasingly popular research design (Simpson, 2011). Journals, articles, and textbooks dedicated to mixed-methods research designs have grown in recent years (Hanson et al., 2005). The idea is to merge the strengths of qualitative and quantitative methods to collect and analyze data (Hanson et al., 2005; Simpson, 2011; Tashakkori & Teddlie, 2003). Particularly in the social sciences, mixed-methods research has emerged as an investigation strategy that is readily used and valued by specialists working in the extensive and diverse fields therein (Creswell, 2003, 2009). Creswell (2009) asserts that due to the multifaceted and complicated nature of research in

the social sciences, quantitative and qualitative strategies working together and building upon one another may be ideal in seeking to understand the variety of phenomena and settings encountered.

Advocates for mixed-methods research propose several benefits of using the approach. Simpson (2011) posits that mixed methods could be used to illuminate unexplained outliers. Interview data might better explain why some quantitative data deviated from the average and might provide the researcher with insight into why particular results were not significant, perhaps due to skewed scores because of validity issues with questions posed in the instrument. Researchers assert that both quantitative and qualitative research methods have stronger and weaker data-collection attributes and, when combined, both can work in unison to counterbalance weaknesses (Hendrickson, Christsen, & Dahl, 1997; Tashakkori & Teddlie, 2003). Hanson et al. (2005) declare that another benefit of mixed-methods designs is that, like quantitative research, they are capable of generalizing findings from a sample to a population. The qualitative component can strengthen the generalization by providing descriptive insight and perspectives from participants that might otherwise be left unknown.

The specific mixed-methods research design I have employed in this study is a sequential explanatory design. The procedural notation is QUAN → qual, created by Creswell (2003) to distinguish a sequential explanatory design from other mixed-methods designs. In a sequential explanatory design, quantitative data are the primary focus and are analyzed first (Creswell, 2009; Hanson et al., 2005; Morse, 2003). Qualitative data are then used to support, clarify, and/or extend quantitative data (Creswell, 2009; Morse, 2003).

The intent of this study was to investigate elementary teachers' receptivity (general attitudes and behavior intentions) toward implementation of integrated STEM education in the elementary grades. Further, the study examined potential relationships between elementary teachers' receptivity and their issues of concern associated with implementing integrated STEM education in the elementary grades, perceived school and other types of support, perceived practicality of implementing integrated STEM education in the elementary grades, and teaching experience. Potential differences among elementary teachers' receptivity were also investigated in relation to subgroups determined by demographic data (i.e., assigned grade level, teaching assignment, years of certified school teaching experience, school Title I eligibility, and school STAR performance rating). A survey instrument was developed to collect these data, as well as demographic data that differentiated participants and provided the basis for individual and school sub-groupings (i.e., grade level assignment, teaching assignment, school teaching experience, Title I eligibility, and school STAR performance rating).

STAR ratings are principally based on students' performance in mathematics, reading, and science. However, proficiency and growth of varied demographic groups (e.g., ethnic/minority students, students with special needs, and ESL students) are considered during the evaluation process. All schools are rated and given a one through five STAR rating based on their total index score with five stars representing the highest-performing schools and one star representing the lowest-performing schools (School District Website, 2013).

Following quantitative data analysis, semi-structured interviews were conducted with a subsample of eight teacher volunteers. Initially, the researcher intended to seek a

sample of eight volunteers that represented a diverse population within the parameters of the demographic data collected. That is, if possible, the researcher planned to invite volunteers from each demographic subcategory: teaching experience (novice, veteran); current grade level assignment (primary, intermediate); and Title 1 eligibility (yes, no). Because only eight participants volunteered for an interview, all eight were selected. However, the eight participants were evenly split along present teaching assignment and teaching experience (4 = primary and 4 = intermediate; 4 = novice and 4 = veteran). Conversely, all eight participants interviewed worked at Title 1 eligible schools. Thus, interview participants represented five of the six aforementioned demographic categories.

Participants and Recruitment Procedures

Participants for this study were, at the time of data collection, certified elementary in-service teachers employed in K-5 or K-6 elementary schools in a large school district located in a (medium-sized) city within the western United States. They were purposely selected for this study due to their chosen profession as an elementary teacher, current teaching position as a certified general, special, and ESL education teacher, the large number of potential participants in the school district in which they were employed, and accessibility to the researcher. Following approval from the appropriate channels, an email was sent to all principals with attached approval letters and a link to the online survey instrument to forward to all certified general, special, and ESL education teachers in their schools. Following completion and submission of the survey, participants had an opportunity to volunteer for a follow-up interview. Because the research software downloaded survey data before the interview option was posed, potential interviewees' survey data remained anonymous. Eight participants who volunteered to participate in a

follow-up interview were selected to participate. Selection based on demographic diversity was disregarded due to the low number of interview volunteers. However, the eight participants were evenly split along present teaching assignment and teaching experience (4 = primary and 4 = intermediate; 4 = novice and 4 = veteran). Conversely, all eight participants interviewed worked at Title 1 eligible schools. Thus, interview participants represented five of the six demographic categories originally sought. Individual interviews were conducted face-to-face in participants' classrooms in the schools at which they taught. These semi-structured interviews lasted 15-20 minutes each.

Tables 1-5 show participants' demographic data collected from the survey instrument. Table 6 shows demographic data of participants that volunteered for an interview. Table 1 presents participants' grade-level assignments.

Table 1

Grade-Level Classification of Survey Participants

Grade-Level Categories	Frequency	Percent
Primary General Education (K-3)	99	54.7
Intermediate General Education (4-6)	82	45.3
Total	181	100.0

Table 2 shows survey participants' teaching assignments.

Table 2

Teaching Assignment Classification of Survey Participants

Assignment Categories	Frequency	Percent
General Education Teachers	140	77.4
Special Education Teachers	31	17.1
English as a Second Language (ESL) Education Teachers	10	5.5
Total	181	100.0

Table 3 presents the categorization of teachers as either novice or veteran based on their certified teaching experience.

Table 3

Teaching Experience of Survey Participants

Teaching Experience	Frequency	Percent
Novice: 0-7 years	85	47.0
Veteran: > 7 years	96	53.0
Total	181	100.0

Table 4 displays the number of participants employed in either a Title I eligible school or a Title I non-eligible school.

Table 4

Title 1 Eligibility of Schools Where Survey Participants Work

Title 1 Eligibility of School	Frequency	Percent
Eligible	97	53.6
Non-eligible	84	46.4
Total	181	100.0

Table 5 shows the number participants that work in a 1-2, 3, or 4-5 STAR-performance-rated school.

Table 5

Star Performance Rating of Schools Where Survey Participants Work

Star Rating of Schools	Frequency	Percent
1-2 Stars	34	18.8
3 Stars	101	55.8
4-5 Stars	46	25.4
Total	181	100.0

Note. STAR ratings are principally based on students' performance in mathematics, reading, and science. However, proficiency and growth of varied demographic groups (e.g., ethnic/minority students, students with special needs, and ESL students) are considered during the evaluation process. All schools are rated and given a one through five STAR rating based on their total index score with five stars representing the highest-

performing schools and one star representing the lowest-performing schools (School District Website, 2013).

School District Information

Participants recruited for this study work in a school district comprised of 94 schools. Of those schools, 64 are elementary. The majority of the schools reside in suburbs surrounding a city, but some are located in rural areas due to the size of the county. As of the 2012-2013 calendar year, the school district was one of the largest employers in the state. About 50% of all employees were licensed educators, nurses, or counselors. Of those that were licensed, a little more than half had earned graduate degrees. During the same school calendar year (2012-2013), there were just over 62,000 students enrolled in the school district. The student body is relatively diverse, with approximately a 50-50 split between racial/ethnic minority students and White students (School District Website, 2013)

Table 6 provides the demographic data of participants that volunteered for interviews.

Table 6

Demographic Data of Teachers Who Participated in Follow-up Interviews

Participant	Teaching Experience	Grade Level Assignment	Teaching Assignment	School Title 1 Eligibility	School STAR Rating
Teacher A	Novice (7)	Primary (K)	General Ed.	Title 1	2
Teacher B	Veteran (15)	Primary (1st)	General Ed.	Title 1	2
Teacher C	Veteran (9)	Primary (1st)	General Ed.	Title 1	2
Teacher D	Veteran (13)	Intermediate (6th)	General Ed.	Title 1	3
Teacher E	Novice (6)	Intermediate (5th)	General Ed.	Title 1	3
Teacher F	Novice (7)	Primary (3rd)	General Ed.	Title 1	3
Teacher G	Novice (3)	Intermediate (4th)	General Ed.	Title 1	3
Teacher H	Veteran (13)	Intermediate (4th)	General Ed.	Title 1	3

Note. The numbers in parentheses in the teaching experience column represent the number of completed years of certified teaching experience.

Note, that not all demographic subgroups were represented among these participants due to the low numbers that volunteered to be interviewed. However, five of the six of the original targeted subgroups were represented (i.e., novice and veteran teachers, primary and intermediate teachers, and teachers working in Title 1 schools). There is balance among the teaching experience and teaching grade level subgroups. Further, general education teachers, teachers working at Title 1 eligible schools, and teachers working at lower performing (2 STARs) and average performing schools (3 STARs) are represented in the sample. These teachers responded to five open-ended questions that sought their perceptions, insight, and concerns about the possible adoption and implementation of integrated STEM education in the elementary grades.

Data Gathering Procedures

Following approval to conduct the study from the University of Nevada, Reno's (UNR) Institutional Review Board (IRB), the IRB approval notification was sent to the human resources department of the targeted school district to seek their approval to conduct a study. Subsequent to approval from the school district, an email was sent to all elementary school principals (n = 64). Emails included attached approval letters from UNR's and the school district's research-approval departments, as well as a link to the online survey instrument. Principals were asked to forward the link to all certified K-6 teachers working in their schools in any capacity (e.g., intervention specialist, music, general, special, and ESL education teachers). The email briefly described the study and invited teachers to take the online survey via a direct link. The survey was available to teachers for a 21-day period. Reminder emails for participation were sent to principals to forward to their teachers one week after the initial email and again three days prior to the end of the 21-day period.

In addition, hardcopies of flyers that sought teachers' participation and provided a link to the study were delivered to the elementary schools. Secretaries were asked to place the flyers in teachers' mailboxes. Permission was also sought from the elementary school principals to post the aforementioned flyer in school-wide staff rooms and for the researcher to speak briefly (5 minutes) at one staff meeting to recruit study participants.

Following survey completion, participants were invited to participate in a face-to-face interview. So that survey data remained anonymous, those participants that wished to volunteer for the interview had to log out of the survey prior to being redirected to a separate page where they were asked to provide their contact information. Teaching

experience and grade level was sought as part of the contact information so that the researcher could differentiate among volunteers to pursue interviews with those representing at least one of each of six categories (i.e., School Title 1 eligibility, yes or no; teaching experience, novice or veteran; and grade level assignment, primary or intermediate). Title 1 eligibility was accessed through the school district's website once names were provided. Interview participants were contacted approximately one week after the 21-day survey completion period. A mutually convenient time and place was decided upon to conduct a 15-20-minute, face-to-face, semi-structured interview.

Instrumentation

The survey instrument (Appendix A) was formatted and uploaded to SurveyMonkey's research software (see https://www.surveymonkey.com/), which permitted the researcher to post and participants to take the survey online. Participants completed a 35-item, seven-point Likert-type survey instrument titled, *Elementary Teachers' Receptivity to integrated STEM Education in the Elementary Grades*. The survey was adapted from Waugh and Godfrey's (1993, 1995) receptivity to change instruments and Lee's (2000) receptivity to change instrument, which was also adapted from Waugh and Godfrey's (1993) original receptivity to change instrument. See Appendix C for citations of studies and original Likert-type items from which modifications were made for this study's survey instrument. Utilizing a survey instrument in research can provide an efficient means to collect credible data from a selected sample on most questions posed, the findings for which can then be generalized to a larger population. Survey research is used in many professional areas to acquire various types of information (e.g., anything from political opinions to personal habits). In education, and

especially in doctoral dissertation studies, survey research is a prevalent technique for collecting data (McMillan & Schumacher, 2006).

For the first nine items, participants chose a rating response along a seven-category semantic differential (a variation of the Likert scale) that fell between adjective pairs representing opposite ends of an attitudinal spectrum (McMillan & Schumacher, 2006). The remaining survey items used a seven-point Likert scale. Participants specified whether they disagree very strongly, disagree strongly, disagree, are neutral, agree, agree strongly, or agree very strongly. The Likert scale is the most popular scaled item used in research. It affords reasonably reliable data on participants' beliefs and opinions. This is due to the gradation nature of peoples' beliefs and opinions, which often fall along a spectrum that spans the bidirectional values of the descriptors on the Likert scale. Further, Likert scales are adaptable; they can be tailored to align with the nature of questions or statements (McMillan & Schumacher, 2006).

The survey instrument initially defines integrated STEM education in a brief paragraph. Breiner et al. (2012) contend that there may be confusion among educators about what integrated STEM education is because of the recent notoriety and liberal use of the acronym, as well as content bias in academic and universal discussions. Therefore, a definition of integrated STEM education was presented to provide some clarity to participants before taking the survey.

The survey instrument is organized into five indices (Appendix A). The first index is comprised of nine items that relate to participants' general attitudes toward STEM education in the elementary grades. The second index has six items that relate to participants' behavioral intentions toward possible implementation of integrated STEM

education in the elementary grades. In order to keep participants focused on the survey questions and statements and to prevent the temptation of automatically checking the same descriptor for all the items within an index or on the survey, two items in the behavior intentions index, S10 and S13, are purposely stated to have opposite meaning (negative keyed) from the other items in this section. Chen, Dedrick, and Rendina (2007) posit that negatively keyed items cause "cognitive speed bumps" for participants, which facilitate the management of participants' thought processes in a more controlled manner while they are taking the survey. Further, negatively keyed items reduce response bias as long as all scale index items (positively and negatively keyed) assess the same characteristic or concept. Thus, the scale values were reversed (1-7 to 7-1) for these two items (S10 and S13) before the analyses were conducted. The third index has eight items that relate to the degree to which participants believe general support is in place to assist them at their schools and to what degree they perceive others will support possible implementation of integrated STEM education in the elementary grades. The fourth index has six items that relate to participants' perceived practicality of implementing integrated STEM education in their schools/classrooms. The fifth and final index has six items that relate to potential concerns associated with implementing integrated STEM education at the elementary grade levels.

The last part of the survey asked participants for routine demographic data about themselves and the school in which they taught at the time of the study. Information was requested concerning the number of years of certified teaching experience, current grade-level assignments, current teaching assignment, current school STAR performance rating, and school Title 1 eligibility. These data helped the researcher categorize participants by

grade-level, teaching experience, and type of school in which they were employed (i.e., Title 1 eligible or not, and STAR performance rating of low, on level, and high, which are designated by 1-5 stars). In addition, these subgroups were examined for possible differences in teachers' receptivity (general attitudes and behavior intentions) toward implementing integrated STEM education in the elementary grades.

Table 7 aligns the quantitative research questions for this study (1-3), the survey item intended to provide the data to inform them, and the data analyses conducted. Just item numbers are provided here. Please see Appendix B for item statements or questions, research questions, and data analyses alignment.

Table 7

Research Question, Survey Item, and Analyses Alignment

Research Question	Survey Items (S)	Data Analysis
1. What is elementary teachers' degree of receptivity to implementing integrated STEM education in the elementary grades?	R1 For items S1-S9, indicate your viewpoint concerning implementation of STEM education into the elementary grade levels. (Note: For the first nine items (S1-S9), participants provided ratings to indicate their responses to items appearing on a semantic differential scale that included adjective pairs at opposite ends of an attitudinal spectrum with seven rating points between them. See Appendix B for items sources. **Attitude:** S1: undesirable/desirable S2: not valuable/valuable S3: foolish/wise S4: unreasonable/reasonable S5: unrealistic/realistic S6: unimportant/important S7: unnecessary/necessary S8: boring/exciting S9: unwanted/wanted **Behavioral Intentions:** Note: For the remainder of the items, participants specified whether they disagree very strongly, disagree strongly, disagree, are neutral, agree, agree strongly, or agree very strongly. Behavior intentions scale consisted of items S10 through S15 (n = 6) See Appendix B for each item statement or question and sources.	Descriptive

Research Question	Survey Items (S)	Data Analysis
2. What differences, if any, exist among selected elementary teacher subgroups in receptivity to	**Attitude**: S1-S9 (listed above) **Behavioral Intentions**: S10-S15 (listed above) Demographic and School Categories: Obtained from the following demographic data: **Teaching experience** (novice, veteran)	Independent t-test Mann-Whitney U One-way Analysis of Variance

implementing integrated STEM education in the elementary grades?	**Teaching assignment** (general, sped, ESL) **Grade-level assignment** (primary, intermediate) **School STAR rating** (1-2, 3, 4-5); 1= lowest rating, 5 = highest rating) **School Title 1 eligibility** (yes or no)	

Research Question	Survey Items (S)	Data Analysis
3. What relationships, if any, exist between elementary teachers' receptivity and concerns associated with implementing integrated STEM education in the elementary grades and their perceived school and other types of support, perceived practicality of implementing STEM education in the elementary grades, and teaching experience?	Attitude: S1-S9 (listed above) Behavioral Intentions: S10-S15 (listed above) **Perceived School/Other Support:** Perceived school/other support scale consisted of items S16 through S23 (n = 8) See Appendix B for each item statement or question and sources. **Perceived Practicality:** Perceived practicality scale consisted of items S24 through S29 (n = 6) See Appendix B for each item statement or question and sources. **Issues of Concern:** Issues of concern scale consisted of items S30 through S35 (n = 6) See Appendix B for each item statement or question and sources.	Pearson product-moment correlations Multiple regression

Note. Just the survey item numbers are provided here. Please see Appendix B for item statements or questions. In addition, see Appendix C survey items sources and adaptations.

Reliability. Dimitrov (2010) maintains:

> In general, the reliability of measurements indicates the degree to which they are accurate, consistent, and replicable when (a) different people conduct the measurement, (b) using different instruments that purport to measure the same trait, and (c) there is incidental variation in measurement conditions. That is, the reliability of scores shows the degree to which they are "free" of random error (p. 23).

In simpler terms, reliability reflects the ability of a study to remain true to its original findings should the study be replicated by others with different instruments that measure the same thing in similar settings (Drost, 2011).

Internal consistency measures the reliability of an instrument's items. It provides a measure of how well a set of items or all the items within an instrument align with the intended behavior or characteristic being measured (Drost, 2011). Cronbach's alpha coefficient (Cronbach, 1951) is generally viewed as the best-suited reliability indicator for survey research (Drost, 2011; McMillan & Schumacher, 2006). Thus, Cronbach's alpha coefficient was used to assess the degree of internal consistency of the survey items on the instrument. The Cronbach's alpha reliability coefficient calculations most often fall within the range of 0 to 1, but it is possible to compute a negative score that falls below the conventional lower limit (Thompson, 2003). The larger the number—nearer to 1—the better the internal consistency of the survey items (Santos 1999; Sprinthall, 2007). George and Mallory (2003) have provided a generally accepted basis for evaluating

Cronbach's alpha reliability coefficient scores: $\alpha > 0.9$ (Excellent), $\alpha > 0.8$ (Good), $\alpha > 0.7$ (Acceptable), $\alpha > 0.6$ (Questionable), $\alpha > 0.5$ (Poor), and $\alpha < 0.5$ (Unacceptable).

To assess the degree of internal consistency of the items on this study's survey instrument, Cronbach's alpha coefficients were run on the survey items as a whole and on each of the five item groupings (indices). The instrument and all scale indices proved to have excellent reliability (see table 8). The scale indices provided data for the dependent and the independent variables. The dependent variables include two subcategories of teachers' receptivity: (a) attitudes toward integrated STEM education, survey items 1 through 9 and; (b) behavioral intentions toward integrated STEM education, survey items 10 through 15. The independent variables include: (c) perceived school and other support, survey items 16 through 23; (d) perceived practicality, survey items 24-29; and (e) issues of concern, survey items 30-35.

Table 8

Reliability of "Elementary Teachers' Receptivity to integrated STEM Education" Instrument and the Five Indices that Comprise the Instrument

Receptivity of STEM Indices	*n* Items per Scale Index	Reliability (Chronbach's α)
Attitudes	9	.978
Behavior Intentions	6	.935
Perceived School/Other Support	8	.929
Perceived Practicality	6	.960
Issues of Concern	6	.905
Total items	35	.930

Validity. Validity indicates whether an instrument measures what it alleges to measure. For example, does the first scale index of this survey measure elementary teachers' attitude toward integrated STEM education, or does it measure something else? If this survey measures what it claims to measure, then it is accepted that the instrument has test validity (Sprinthall, 2007). Face validity will be used in order to assure test validity. Face validity is subjective; it is the analysis of an instrument by informed or expert (in the area of the study's inquiry) volunteers to validate the questions and/or statements therein. Volunteers assess whether or not the questions were clear, appropriate, and/or relate to the intended purpose of the study, among other things (Drost, 2011).

Pilot Study. Three experienced elementary teachers evaluated the survey instrument prior to its use. Feedback was given regarding comprehensibility, readability, appropriateness of the survey questions, and whether or not the items aligned with survey section headings. For example, do the questions in the section "perceived practicality of integrated STEM education in the elementary grades" actually seek information regarding teachers' perceived practicality of integrated STEM education in the elementary grades? Moreover, teachers provided feedback on how to strengthen the instrument. For example, a teacher suggested that questions that use negative verbs to describe potential behavioral intentions toward the implementation of integrated STEM education should be added to the behavioral intentions index to keep participants "honest." This feedback was considered and much of it was used to better the instrument's face validity.

Data Analysis Procedures

Quantitative Procedures

A 35-item, 7-point Likert-type scale survey, adapted from Waugh and Godfrey's (1993, 1995) and Lee's (2000) receptivity to change survey instruments, was used to collect quantitative data. It should be noted that Likert (1932), the creator of the Likert scale, developed a 5-point Likert scale and thus the 7-point Likert scale used in this study is a variation of the original (Boone & Boone, 2012; Clason & Dormody, 1994). For the first nine survey items, participants provide a response along a seven-point semantic differential located between adjective pairs on opposite ends of an attitudinal spectrum (McMillan & Schumacher, 2006). The remaining survey items are on a seven-point Likert scale. Values 1-7 are assigned to each of the descriptors, starting with disagree very strongly and ending with agree very strongly. All of the descriptors are as follows: disagree very strongly, disagree strongly, disagree, neutral, agree, agree strongly, and agree very strongly. However, due the intentional use of negative keyed items used in the behavior intentions index (Likert-type items S10 and S13), the scale values were reversed before analyses were conducted (e.g., 7 = disagree very strongly and 1 = agree very strongly).

According to Clason and Dormody (1994), Likert scale refers to Likert-type items (statements or questions) designed to grasp a better understanding of participants' attributes. However, although there tends to be a lot of confusion concerning this, Likert scale does not refer to the displays of the points (i.e., 5-point or 7-point or adding or subtracting the neutral position); these are simply alternatives or variations of the original 5-point Likert scale. Boone and Boone (2012) maintain that a Likert scale is made up of

more than four Likert-type items that are intentionally designed to represent a characteristic or personality trait of participants. Allen and Seaman (1997) assert that five to seven Likert-type items are ideal to make up a Likert scale. These Likert-type items are combined (summed or averaged) to provide a single score. When Likert scales are used and meet an acceptable degree of internal consistency (i.e., $\alpha > .7$), then data may be analyzed as an interval scale, and thus parametric statistics can be used (Allen & Seaman, 2007; Baggaley & Hull, 1983; Boone & Boone, 2012; Carifio & Perla, 2007).

Therefore, descriptive statistics, reliability analysis, independent t-test, Mann-Whiney U, one-way analysis of variance (ANOVA), Pearson product-moment correlations, and linear multiple regression analyses were conducted using SPSS software. Through providing means, standard deviations, and frequency counts, descriptive statistics illustrated the degree of elementary teachers' receptivity to integrated STEM education in the elementary grades. Average scores above 4.0 (scale neutral) on both the attitude and behavior intention indices indicated positive receptivity; conversely, averages below 4.0 signified negative receptivity.

To determine whether receptivity differences, if any, existed among subgroups of elementary teachers, independent t-test, Mann-Whitney U, and one-way analysis of variance (ANOVA) statistical analyses were used. An independent t-test was used when exactly two means were compared. When more than two means were compared, a one-way ANOVA was used. Subgroups were formed by: (a) teaching experience, novice ≤ 7 and veteran > 7 years; (b) grade-level assignment, primary or intermediate; (c) teaching assignment, general education, special education, or ESL education; (d) school's Title I eligibility, eligible or non-eligible; and (e) school's STAR (performance) rating, 1-2, 3, 4-

5 stars. Levene's test for homogeneity of variance is an assumption that is required if there are unequal *n*'s, which was the case for all selected subgroups paired in this study. Due to a finding of no homogeneity of variance and unequal *n*'s for two compared subgroups, an independent t-test was determined unfit for analysis. Thus, a Mann-Whitney U test was employed with significance set at the .05 alpha level. When analyses showed significance, Cohen's d or eta squared (η^2) was calculated to test the strength of significant results using effect size. Cohen (1988) declared the main effect conventions as follows for eta squared: 0.01 = small effect, 0.06 = medium effect, and 0.14 = large effect.

To determine what relationship, if any, existed among elementary teachers' receptivity, comprised of general attitude and behavior intentions (dependent variables), and issues of concern associated with implementing integrated STEM education, perceived school and other types of support, perceived practicality for implementing integrated STEM education in the elementary grades, and years of teaching experience (independent variables), Pearson product-moment correlations were computed to show the degree of strength and the direction of the relationship between variable pairs (McMillan & Schumacher, 2006; Sprinthall, 2007). SPSS provided the means to test whether these data met appropriate assumptions before correlation analyses were conducted. A Shapiro-Wilk test was used to test data for normality; further, bivariate scatterplots were created in SPSS for all dependent and independent variable pairings to confirm that the data were free of outliers and to examine data for linearity and homoscedasticity.

To identify the amount of variability in general attitude and behavior intentions by the linear combination of issues of concern associated with implementing integrated STEM education, perceived school and other types of support, and perceived practicality of integrated STEM education in the elementary grades, multiple regression analysis was conducted. Multiple regression analysis detected whether or not the linear combination of independent variables was predictive of each criterion (dependent) variable. (See Figure 1 for a visual presentation of correlation and regression analyses conducted.) Data were tested to confirm that they met appropriate assumptions before multiple linear regression was deemed appropriate for analysis. A Shapiro-Wilk test concluded that the data met the assumption of normality. Further, scatterplots for each dependent and independent variable pairing showed that the data were free of outliers and met the assumptions of linearity and homoscedasticity. Finally, collinearity statistics were ran and analyzed to test for multicollinearity among independent variables.

Figure 1 shows the correlation and regression analysis conducted for this study. Variable pairings (dependent and independent) for the correlation analyses are displayed and the linear combination of the predictor variables and both criterion variables used in the multiple regression analysis are presented.

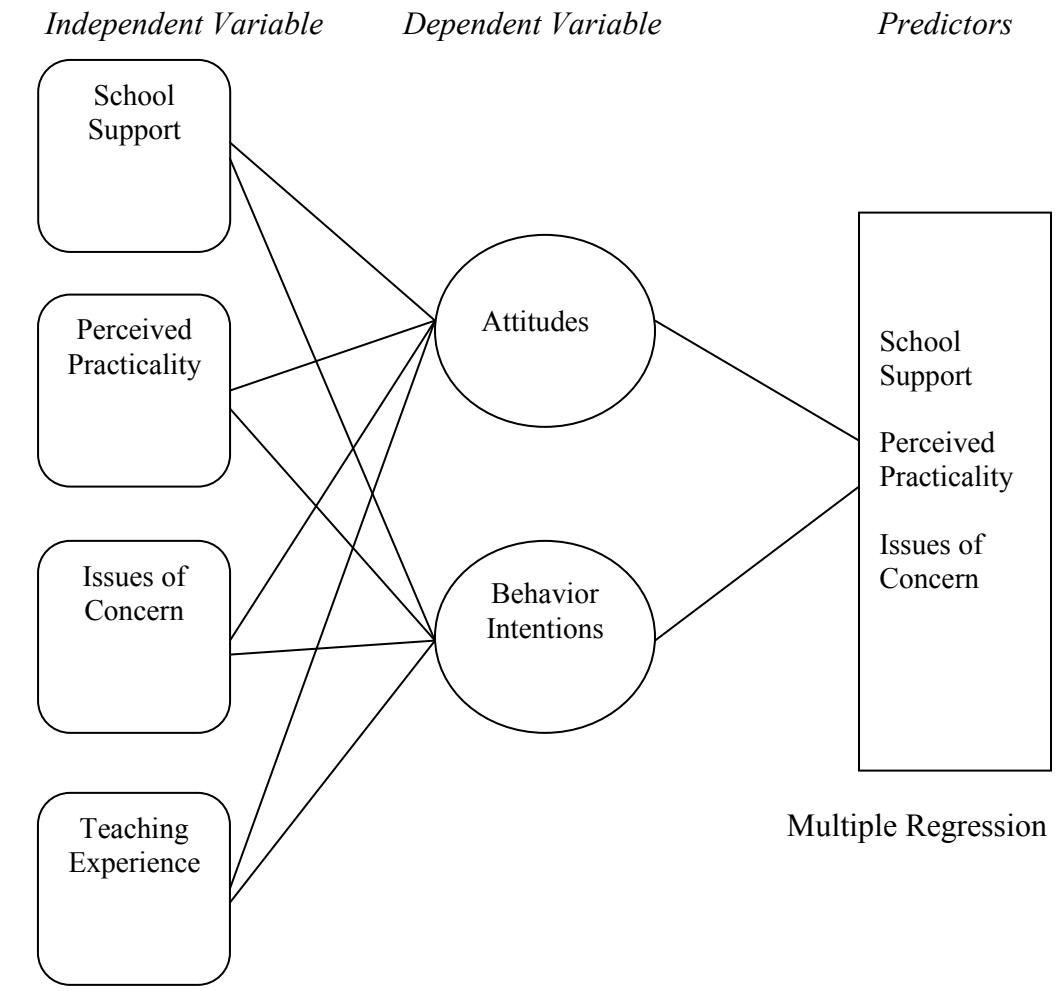


Figure 1. Each independent variable (IV) was paired with each dependent variable (DV) for the correlation analysis. However, the linear combination of three of the IVs (predictors) was used to predict each of the DVs (criterion variables).

Qualitative Procedures

Semi-structured interviews were conducted with the eight teachers who volunteered to be interviewed following the collection of the survey data. The intention was to select teachers from across six demographic categories, if achievable (i.e., works at Title 1 eligible school or not; teaching experience, novice or veteran; and current grade level assignment, primary or intermediate). However, this was not possible due to the low

number of participants (n = 8) that volunteered for an interview. Interviews were conducted individually at each participant's school at his/her convenience and took approximately 15-20 minutes to complete for each participant. Questions were prepared and given to teachers via email two to three days prior to the face-to-face interviews so that teachers had the opportunity to think about, prepare their responses, and to ease any anxiety teachers might of had regarding the types of questions they would be asked. The questions were prepared to elicit teachers' responses concerning their perceptions, concerns, and recommendations for possible implementation of integrated STEM education into the elementary grades. At times, the researcher asked participants questions to clarify, elaborate, and/or extend their initial responses.

All interviews were audio recorded. Following each interview, the researcher transcribed the recorded data. Once all interviews were completed and transcribed, data were reviewed for themes that appeared across participants. Similar themes were assigned codes, which were then organized into categories. Finally, categories were summarized and described (Burnard, 1991; Shank, 2006). Validity issues were addressed by observing data first-hand, one-on-one, in informal settings, and from trustworthy participants (Shank, 2006).

Chapter Four

Data Analysis and Results

This study investigated elementary teachers' degree of receptivity (attitude and behavioral intentions) to integrated STEM education in the elementary grades prior to formal approval and declaration of its implementation in elementary schools. Differences, if any, in elementary teachers' receptivity among subgroups were determined by personal and school demographic variables (i.e., assigned grade level, primary, intermediate; teaching assignment, general, special, or ESL; certified school teaching experience; school Title I eligibility, eligible, non-eligible; and school STAR performance rating, 1-2, 3, or 4-5) using a survey containing 35 items requiring item ratings. In addition, this study explored the relationship between elementary teachers' receptivity to integrated STEM education and their concerns associated with implementing integrated STEM education, perceived school and other types of support, perceived practicality of integrated STEM education in the elementary grades, and certified teaching experience. Finally, individual interviews were conducted with eight volunteers from among those who completed the survey. These teachers responded to open-ended questions pertaining to their perceptions, insights, and concerns associated with implementation of integrated STEM education in the elementary grades. This chapter presents quantitative data analysis methods and results, followed by qualitative analysis and results.

Descriptive statistics were the measure used to determine the degree of elementary teachers' receptivity to integrated STEM education in the elementary grades. Average scores above 4.0 (scale neutral) on both the attitude and behavior intentions' indices indicate positive receptivity. Conversely, average scores less than 4.0 on one but

not the other index or both indices signified negative receptivity. Frequencies and percentages of elementary teachers with positive receptivity toward integrated STEM education in the elementary grades are presented. Further, descriptive statistics are provided for participants who had average scale index scores above 4.0 in one of the scale indexes but not the other (attitude or behavior intentions).

To address differences, if any, among elementary teachers' receptivity in subgroups, independent samples t-test, Mann Whitney U, and one-way analysis of variance (ANOVA) statistical analyses were conducted. Subgroups were organized by: (a) teaching experience, novice ≤ 7 and veteran > 7 years; (b) grade level assignments, primary or intermediate; (c) teaching assignments, general education, special education, and English as a Second Language (ESL) education; (d) school's Title I eligibility, eligible or non-eligible; and (e) school's STAR performance rating, 1-2, 3, 4-5 stars.

To determine what relationship, if any, existed among elementary teachers' receptivity (general attitudes and behavioral intentions) and issues of concern associated with implementing integrated STEM education, perceived school and other types of support, perceived practicality of integrated STEM education in the elementary grades, and teaching experience, Pearson product-moment correlation analysis was utilized.

To determine how well the linear combination of teachers' issues of concern associated with implementing STEM education, perceived school and other types of support, and perceived practicality of integrated STEM education in the elementary grades predicted teachers' attitudes or behavior intentions toward integrated STEM education in the elementary grades, multiple regression analysis was conducted. General attitudes and behavior intentions are recognized as separate variables of receptivity; thus,

they were designated as separate dependent (criterion) variables in the regression analyses.

Finally, eight interviews were conducted with teachers who participated in the survey. Interviews were conducted to further explore, explain, and expand quantitative data. Using Shank's (2006) protocol for analyzing qualitative data, each interview was audio recorded and transcribed. All data were reviewed for themes that appeared across participants. Similar themes among participants were assigned codes, which were then organized into categories based on questions posed. Finally, categories were summarized and described in a narrative supported by illustrative quotes.

Research Question One

What is elementary teachers' degree of receptivity to implementing integrated STEM education in the elementary grades?

First, descriptive statistics and frequency distributions for the nine items that make up the attitude scale index and the six items that make up the behavior intentions index are presented in Tables 8 and 9. Second, frequency distributions and percentages of teachers with positive receptivity, positive attitude only, positive behavior intentions only, and those teachers that indicated negative receptivity (mean scale score of less than 4.0 on the attitude and behavior intentions scale indices) are displayed in Table 10. Finally, descriptive statistics are provided to show elementary teacher participants' average degree of receptivity toward integrated STEM education in the elementary grades.

On the attitude scale index, the first nine survey items, participants chose a rating response along a seven-level semantic differential (a variation of the Likert scale) that fell

between nine adjective pairs representing opposite ends of an attitudinal spectrum (1= negative adjective description, 4 = neutral, and 7 = positive adjective description). The adjective pairs include: (S1) undesirable/desirable; (S2) not valuable/valuable; (S3) foolish/wise; (S4) unreasonable/reasonable; (S5) unrealistic/realistic; (S6) unimportant/important; (S7) unnecessary/necessary; (S8) boring/exciting; (S9) unwanted/wanted. Table 9 shows frequency distributions and descriptive statistics for all nine items in the attitude scale index.

Table 9

Descriptive Statistics and Frequency Table for the Nine Attitude Index Items, Survey Items 1-9

Survey Items	*M*	*SD*	Very Strongly Disagree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Very Strongly Agree	Total
S1	5.10	1.3	1 (.6%)	3 (1.6)	22 (12.2)	26 (14.3)	53 (29.3)	50 (27.6)	26 (14.4)	181 (100)
S2	5.23	1.2	0 (0%)	3 (1.7%)	17 (9.4%)	26 (14.4%)	52 (28.7%)	55 (30.4%)	28 (15.4%)	181 (100)
S3	5.14	1.2	3 (1.7%)	2 (1.1%)	12 (6.6%)	34 (18.8%)	54 (29.8%)	50 (27.6%)	26 (14.4%)	181 (100)
S4	5.03	1.2	1 (.6%)	4 (2.2%)	17 (9.4%)	38 (21.0%)	51 (28.2%)	45 (24.9%)	25 (13.8%)	181 (100%)
S5	4.87	1.2	3 (1.7%)	3 (1.7%)	17 (9.4%)	41 (22.7%)	57 (31.5%)	46 (25.4%)	14 (7.7%)	181 (100%)
S6	5.25	1.2	0 (0%)	2 (1.1%)	18 (9.9%)	28 (15.5%)	46 (25.4%)	57 (31.4%)	30 (16.6%)	181 (100%)
S7	5.09	1.3	3 (1.7%)	2 (1.1%)	21 (11.6%)	27 (14.9%)	48 (26.5%)	55 (30.4%)	25 (13.8%)	181 (100%)
S8	5.28	1.3	1 (.6%)	1 (.6%)	16 (8.8%)	33 (18.2%)	44 (24.3%)	49 (27.1%)	37 (20.4%)	181 (100%)
S9	5.01	1.3	2 (1.1%)	3 (1.7%)	24 (13.3%)	26 (14.4%)	56 (030.9%)	47 (26.0%)	23 (12.7%)	181 (100%)

Note. S1 represents survey item one; $n = 181$.

Approximately 70% of all nine items in the attitude index was rated as a five or more by the elementary teacher participants regarding their general attitude to implementing integrated STEM education in the elementary grades. However, approximately 18% rated their general attitudes as a four, or neutral to the idea, and approximately 12% rated their general attitude at a three or less on each of the nine items. On item S5 (unrealistic/realistic), 22.7% of participants rated their attitude as neutral, which was more than on any other item in the scale. Further, fewer participants (9.4%) rated the implementation of integrated STEM education in the elementary on the foolish side of the spectrum (three or less) on item S3 (foolish/wise) than any other item. Finally, more participants (74.5%) rated integrated STEM education in the elementary grades on the valuable side of the spectrum (five or more) for item S2 (non-valuable/valuable) than any other item on the attitude scale index.

On the behavior intentions scale index, survey items S10-S15, a seven-point Likert scale was used. Participants specified whether they: disagree very strongly, disagree strongly, disagree, were neutral, agree, agree strongly, or agree very strongly. Note that items S10 and S13 are purposely stated to have opposite meaning (negative keyed) from the other items (positive keyed) in behavior intentions' index. Thus, the Likert scale values were reversed (1-7 to 7-1) for these two items before analyses were calculated. Table 10 shows frequency distributions and descriptive statistics for all six items in the behavior intentions scale index. However, behavioral intentions Likert-type items (survey statements) are provided first:

S10: In my actions and communication with other staff, I will probably actively and openly oppose the implementation of appropriately leveled integrated STEM education into the K-6 grade levels.

S11: In my actions toward and communication with other staff, I will probably actively and openly support the adoption and implementation of appropriately leveled integrated STEM education into the K-6 grade levels.

S12: In my actions toward and communication with other staff, I will probably praise the adoption and implementation of appropriately leveled integrated STEM education into the K-6 grade levels.

S13: In my actions toward and communication with other staff, I will probably resist the adoption and implementation of appropriately leveled integrated STEM education into the K-6 grade levels.

S14: In my actions toward and communication with other staff, I will assume the stance that adopting and implementing appropriately leveled integrated STEM education in the K-6 grade levels is achievable and hence should be supported.

S15: In my actions toward and communication with other staff, I will assume the stance that integrated STEM education can be adapted to the needs and abilities of students in the K-6 grade levels.

Table 10

Descriptive Statistics and Frequency Table for the Six Behavior Intentions Index Items; Survey Items 10-15

Survey Item	*M*	*SD*	Very Strongly Disagree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Very Strongly Agree	Total
S10	5.14	1.0	23 (12.7%)	33 (18.2%)	85 (47.0%)	29 (16.0%)	10 (5.5%)	1 (.6%)	0 (0%)	181 (100%)
S11	4.83	1.0	0 (0%)	4 (2.2%)	16 (8.8%)	35 (19.3%)	90 (49.7%)	22 (12.2%)	14 (7.7%)	181 (100%)
S12	4.76	1.0	1 (.6%)	2 (1.1%)	16 (8.8%)	43 (23.8%)	88 (48.6%)	19 (10.5%)	12 (6.6%)	181 (100%)
S13	5.11	1.1	22 (12.2%)	38 (21.0%)	77 (42.5%)	31 (17.1%)	10 (5.5%)	2 (1.1%)	1 (.6%)	181 (100%)
S14	4.87	1.0	1 (.6%)	2 (1.1%)	11 (6.1%)	37 (20.4%)	95 (52.5%)	23 (12.7%)	12 (6.6%)	181 (100%)
S15	4.85	1.0	0 (0%)	4 (2.2%)	17 (9.4%)	28 (15.5%)	98 (54.1%)	20 (11.0%)	14 (7.7%)	181 (100%)

Note. S10 represents survey item 10; $n = 181$; because survey items 10 and 13 are negatively keyed, values assigned to the descriptors were reversed from 1-7 to 7-1. Therefore, disagree very strongly was assigned a value of seven and agree very strongly was assigned a value of 1 on survey items 10 and 13 only.

Looking at each of the items separately in the behavior intentions scale index, approximately 70-75% of each of the six items was rated at a five or more by participants regarding their behavior intentions toward implementation of integrated STEM education in the elementary grades. However, approximately 16-24% rated their behavior intentions as a four, or neutral, and approximately 6-11% rated their behavior intentions at a three or less on each of the items. On item S10, more participants (77.9%) rated their behavior intentions at disagree, disagree strongly, or disagree very strongly for openly opposing the implementation of integrated STEM education in the elementary grades. Lastly, more participants (11.6%) were not convinced that integrated STEM education could be adapted to the needs and abilities of students in the K-6 grades—survey item 15.

Table 11 provides frequency distributions for participants who had positive receptivity (mean scores above 4.0 on both the attitude and behavior intentions scale indices), those with mean scores above 4.0 on only the attitude scale index or only the behavior intention scale index, those that rated neutral on both indices, and participants that had negative receptivity to integrated STEM education in the elementary grades (mean score below 4.0 on both the attitude and behavior intentions scale indices).

Table 11

Frequencies Distributions of Positive or Negative Receptivity to Integrated STEM Education in the Elementary Grades

	Frequency	*Percent*
Receptive	139	76.7%
Attitude	5	2.8%
Behavior Intentions	13	7.2%
Neutral (both indices)	2	1.1%
Negative (both indices)	22	12.2%
Total	181	100%

Note. Receptivity (> 4.0 on attitude and behavior intentions); attitude (> 4.0 on attitude only); behavior intentions (> 4.0 on behavior intentions only); neutral (= 4.0 on attitude and behavior intentions); negative (< 4.0 on attitude and behavior intentions).

Overwhelmingly, participants showed positive receptivity (76.7%) to implementing integrated STEM education into the elementary grades. Five (2.8%) of the participants showed positive attitudes but negative behavior intentions. Conversely, 7.2% of the participants showed negative attitudes, but positive behavior intentions. Finally, 1.1% rated themselves as neutral on both the attitude and behavior intentions indices, and 12.2% of the participants rated themselves negative on both indices. However, it should be noted that based on the definition of negative receptivity (negative on either or both indices), 22% of the participants showed negative receptivity to implementing integrated STEM education into the elementary grades.

Table 12 displays descriptive statistics for the overall degree of participants' receptivity (attitude and behavior intentions) to integrated STEM education in the elementary grades. For all participants, means and standard deviations are provided for the general attitude and behavior intentions indices.

Table 12

Overall Participant Receptivity to Integrated STEM Education in the Elementary Grades

Scale Index	*Mean*	*SD*
General Attitudes	5.11	1.1
Behavior Intentions	4.88	.95

Note. $n = 181$

In general, participants' overall average on the attitude scale index was $M = 5.11$, $SD = 1.1$ and on the behavior intentions scale index $M = 4.88$, $SD = .95$ to implementing integrated STEM education into the elementary grades. Both the attitude and behavior intentions overall averages for favorable responses are greater than the scale neutral score of 4.0, which indicates an overall positive attitude and behavior intentions (receptivity) to integrated STEM education in the elementary grades by those who participated in this research.

Research Question Two

What differences, if any, exist among selected elementary teacher subgroups in receptivity to implementing integrated STEM education in the elementary grades?

SPSS provided the means to test data to ensure data met assumptions before analyses were conducted. Box plots were used to check for outliers and the Shapiro Wilk test to test for normality, and homogeneity of variance (Levene's) was tested during analysis. To investigate potential differences in receptivity among participant subgroups,

independent t-test and one-way analysis of variance (ANOVA) statistical analyses were used. However, a Mann-Whitney U was deemed appropriate in place of an independent t-test when subgroups possessed an unequal number of participants and when Levene's test revealed no homogeneity of variance. Subgroups were constructed by: (a) teaching experience, novice ≤ 7 or veteran > 7 years; (b) grade level assignments, primary or intermediate; (c) teaching assignments, general education, special education, or English Second Language (ESL) education; (d) school's Title I eligibility, eligible or non-eligible; and (e) school's STAR (performance) rating, 1-2, 3, or 4-5 stars.

Table 13 provides descriptive statistics and the results from an independent t-test to determine whether a difference existed between novice (≤ 7 years of certified teaching experience) and veteran (> 7 years certified teaching experience) teachers' attitudinal responses toward integrated STEM education.

Table 13

Independent T-test for Attitude by Novice and Veteran Elementary Teachers

	Groups		*t*	*df*	*p*	*d*
	Novice (N = 85)	Veteran (N = 96)				
Attitude	5.37 (1.06)	4.89 (1.25)	2.76	179	.006**	.414

Note. Standard Deviations appear in parentheses below means.

**$p < .01$.

In analyzing receptivity by novice and veteran elementary teachers, a Levene's test showed that there was homogeneity of variance for the attitude index ($p = .169$) but not for the behavior intentions index ($p = .038$). Means and standard deviations were calculated for both novice and veteran teachers ($M = 5.37$, $SD = 1.06$; $M = 4.89$, $SD =$

1.25). An independent t-test showed that novice teachers had significantly more positive attitudes than did veteran teachers toward integrated STEM education in the elementary grades ($t(179) = 2.76$, $p = .006$). Cohen's d was .414, a small effect size.

An independent t-test was determined unfit for analyzing the behavior intentions index by novice and veteran elementary teachers due to the unequal number of participants (novice = 85, veteran = 96) and the lack of homogeneity of variance ($p = .038$) among these subgroups as demonstrated by a Levene's test. Thus, a Mann-Whitney U test was conducted to test for differences between novice and veteran teachers' behavior intentions toward integrated STEM education (see Table 14).

Table 14

Mann-Whitney U Test on Novice and Veteran Elementary Teachers' Behavior Intentions

	Groups		*U*	*df*	*p*
	Novice (N =85)	Veteran (N = 96)			
Behavior Intentions	4.98 (.83)	4.79 (1.05)	8297.0	179	.21

Note. Standard deviations appear in parentheses below means.

*$p < .05$

Means and standard deviations were calculated for both novice and veteran teachers ($M = 4.98$, $SD = .83$; $M = 4.79$, $SD = 1.0$). A Mann-Whitney U test revealed an obtained U of 8297.0, which was found to be not significant ($z = -1.25$, $p = .21$). Thus, novice and veteran teachers do not differ in their behavior intentions toward integrated STEM education in the elementary grades.

Analyzing participants' receptivity by teaching assignment, a Levene's test showed that there was homogeneity of variance for teachers' attitude ($p = .86$) and teachers' behavior intentions ($p = .99$). A one-way analysis of variance was conducted to

determine whether there were significant differences in participants' attitude and behavior intentions toward integrated STEM education in the elementary grades among general education, special education, and ESL education teachers. See Table 15 for results.

Table 15

Analysis of Variance (ANOVA) for Receptivity by Teaching Assignment

Scale Index	Subgroup	*N*	*Mean*	*SD*	Source of Variation	*SS*	*df*	*MS*	*F*	*p*	η^2
Attitude	General Ed.	140	5.28	1.1	Between	17.50	2	8.75	6.54	.002**	.068
					Within	238.18	178	1.33			
	Special Ed.	31	4.53	1.0							
	ESL Ed.	10	5.11	1.1							
Behavior Intentions	General Ed.	140	4.99	.96	Between	7.46	2	3.73	4.20	.016*	.045
					Within	157.92	178	.887			
	Special Ed.	31	4.50	.79							
	ESL Ed.	10	4.53	.99							

Note. *$p < .05$; **$p < .01$

Mean scores indicated that general, special, and ESL teachers had positive attitudes and behavior intentions overall (i.e., overall mean scores above 4.0 on the attitude and behavior intentions scale indices). General education teachers had the highest overall positive attitudes ($M = 5.28$) and behavior intentions ($M = 4.99$), followed by ESL teachers' attitude ($M = 5.11$) and behavior intentions ($M = 4.53$). Overall, special education teachers had the lowest mean score on the attitude scale index ($M = 4.53$) and behavior intentions ($M = 4.50$). In analyzing receptivity by general, special, and ESL teachers, a Levene's test confirmed that there was homogeneity of variance for the attitude scale index ($p = .88$) and for the behavior intentions scale index ($p = .99$). A one-

way analysis of variance was performed to determine whether there were significant differences in attitude and behavior intentions to integrated STEM education among general education, special education, and ESL education teachers. The analysis showed that there was a significant difference in attitude among general, special, and ESL teachers ($F(2, 178) = 6.54$, $p = .002$, $\eta^2 = .068$) and behavior intentions among general, special, and ESL teachers ($F(2, 178) = 4.20$, $p = .016$, $\eta^2 = .045$).

The ANOVA showed significant differences in attitude and behavior intentions among teaching assignments. Due to the unequal number of participants in the sub-groupings, a Scheffe post hoc test (see Table 16) was performed to investigate where attitude and behavior intentions differences occurred among general education, special education, and ESL education teachers.

Table 16

Post Hoc Test for Attitude and Behavior Intentions by Teaching Assignment

Dependent Variable	Teaching Assignment (I)	Teaching Assignment (J)	Mean Difference (I-J)	Error	*p*
Attitude	General Ed.	Special Ed.	.74	.22	.006**
	General Ed.	ESL Ed.	.72	.37	.15
	ESL Ed.	Special Ed.	.01	.42	.99
Behavior Intentions	General Ed.	Special Ed.	.49	.18	.03*
	General Ed.	ESL Ed.	.45	.30	.33
	ESL Ed.	Special Ed.	.03	.34	.99

Note. General Ed. = Teacher assigned to a general education position (e.g., fourth grade teacher).

*p < .05, **p < .01

A Post Hoc test showed that general education teachers had significantly more favorable attitudes and behavior intentions toward integrated STEM education in the elementary grades than did special education teachers. However, there were no differences in attitude and behavior intentions between general education teachers and ESL education teachers. Moreover, there were no differences in attitude and behavior intentions between special education teachers and ESL education teachers.

Table 17 provides descriptive statistics and the results from an independent t-test to determine whether differences existed between primary (grades K-3) and intermediate (grades 4-6) teachers' attitudes and behavior intentions toward integrated STEM education in the elementary grades.

Table 17

Independent T-test for Receptivity by Grade-Level Assignment

	Groups					
	Primary (N = 99)	Intermediate (N = 82)	*t*	*df*	*p*	*d*
Attitude	5.06 (1.3)	5.17 (1.1)	-.596	179	.55	
Behavior Intentions	4.74 (1.0)	5.04 (.82)	-2.084	179	.039*	.32

Note. Standard deviations appear in parentheses below Means.

**$p < .01$

Means and standard deviations show that primary and intermediate teachers had positive attitudes and behavior intentions toward integrated STEM education (i.e., overall mean scores above 4.0 on the attitude and behavior intentions indices). Intermediate teachers (grades 4-6) had higher mean scores on the attitudes index ($M = 5.17$, $SD = 1.1$; $M = 5.06$, $SD = 1.3$) and higher mean scores on the behavior intentions index ($M = 5.04$,

SD = .82; *M* = 4.74, *SD* = 1.0) than primary teachers (grades K-3). In analyzing receptivity by primary and intermediate teachers, a Levene's test confirmed that there was homogeneity of variance for attitude ($p = .41$) and for behavior intentions ($p = .051$). An independent t-test was conducted to determine whether there were significant differences in attitude and behavior intentions toward integrated STEM education by primary and intermediate teachers. There was no significant difference in attitude between primary and intermediate teachers ($t(179) = -.596$, $p = .55$), but there was a significant difference in behavior intentions ($t(179) = 4.34$, $p = .039$). Cohen's *d* was .32, a small effect size.

Table 18 provides descriptive statistics and the results from an independent t-test to analyze potential differences between teachers' attitude toward integrated STEM education for teachers that work in Title 1 eligible schools and those that work in Title 1 ineligible schools.

Table 18

Independent T-test for Attitude by School Title 1 eligibility

	Groups		*t*	*df*	*p*
	Title 1 (N = 97)	Non-title 1 (N =84)			
Attitude	5.12 (1.2)	5.10 (1.0)	.113	179	.91

Note. Standard deviations appear in parentheses below Means.

In analyzing receptivity by school Title 1 eligibility, a Levene's test showed that there was homogeneity of variance for the attitude index ($p = .09$) but not for the behavior intentions index ($p = .038$). An independent t-test was conducted to determine whether there were significant differences in attitude toward integrated STEM education

by teachers that work in Title 1 eligible schools and those that work in Title 1 ineligible schools. No significant difference in attitude appeared between teachers working in Title 1 schools and teachers working in non-Title 1 schools ($t(179) = .113$, $p = .91$).

An independent t-test was determined unfit for analyzing behavior intentions by teachers working in Title 1 or non-Title 1 eligible schools due to the unequal number of participants (Title 1 = 97, non-Title 1 = 84) and the lack of homogeneity of variance ($p = .038$) revealed by a Levene's test. Thus, a Mann-Whitney U test was conducted to analyze potential differences in behavior intentions between teachers that work in Title 1 eligible schools and those that work in Title 1 ineligible schools (see Table 19).

Table 19

Mann-Whitney U for Behavior Intentions by School Title 1 eligibility

	Groups		*U*	*df*	*p*
	Title 1 (N = 97)	Non-title 1 (N =84)			
Behavior Intentions	4.88 (1.0)	4.87 (.95)	7536.0	179	.75

Note. Standard deviations appear in parentheses below means.

Means and standard deviations were calculated for teachers working in Title 1 eligible and in Title 1 ineligible schools (M = 4.88, SD = 1.0; M = 4.87, SD = .95), which yielded nearly identical means. A Mann-Whitney U test resulted in an obtained *U* of 7536.0, which was found to be not significant (z = -.309, p = .75). Thus, teachers working in Title 1 eligible and Title 1 ineligible schools do not differ in their behavior intentions toward integrated STEM education in the elementary grades.

Table 20 shows participants' receptivity by performance STAR rating. A Levene's test showed that there was homogeneity of variance for teachers' attitude ($p =$

.10) and teachers' behavior intentions (p = .26). A one-way analysis of variance was conducted to determined whether there were significant differences in attitude and behavior intentions toward integrated STEM education among teachers working in 1-2 STAR(s) (lower performing), 3 STARs (average performing), and 4-5 STARs (higher performing) schools.

Table 20

One-way Analysis of Variance (ANOVA) for Receptivity by School STAR Performance Rating

Scale Index	Subgroup	*N*	*Mean*	*SD*	Source of Variation	*SS*	*df*	*MS*	*F*	*p*
Attitude	1-2 STARs	34	4.83	1.3	Between	5.28	3	1.76	1.24	.29
				1.1	Within	250.40	177	1.41		
	3 STARs	101	5.24							
				1.2						
	4-5 STARs	45	5.02							
Behavior Intentions	1-2 STARs	34	4.66	1.1	Between	2.64	3	.882	.959	.41
					Within	162.74	177	.919		
	3 STARs	101	4.96	.92						
	4-5 STARs	45	4.86	.91						

Mean scores revealed that teachers working in 1-2, 3, and 4-5 STAR performance rated schools had positive attitudes and behavior intentions toward integrated STEM education (i.e., overall mean scores above 4.0 on the attitude and behavior intentions indices). Teachers working in 3-STAR-rated schools had the highest overall positive attitude (M = 5.24) and behavior intentions (M = 4.96), followed by teachers working in

4-5 STAR-rated schools, attitude ($M = 5.02$) and behavior intentions ($M = 4.86$). Teachers working in 1-2 STAR-rated schools had the lowest mean score in attitude ($M = 4.83$) and behavior intentions ($M = 4.66$). In analyzing receptivity by teachers working in 1-2, 3, or 4-5 STAR-rated schools, a Levene's test confirmed that there was homogeneity of variance for the attitude index ($p = .10$) and for the behavior intentions index ($p = .265$). A one-way analysis of variance was performed to determine whether there were significant differences in attitude and behavior intentions toward integrated STEM education among teachers working in 1-2, 3, and 4-5 STAR-rated schools. No significant differences in attitude appeared among teachers working in 1-2, 3, or 4-5 STAR-rated schools ($F(3, 177) = 1.24$, $p = .29$), nor were there significant differences in behavior intentions by teachers working in different STAR-rated schools ($F(3, 177) = .959$, $p = .41$).

Research Question Three

What relationships, if any, exist between elementary teachers' receptivity and potential concerns associated with implementing integrated STEM education in the elementary grades and their perceived school and other types of support, perceived practicality of implementing integrated STEM education in the elementary grades, and teaching experience?

Various statistical analyses were employed using SPSS to ensure data met assumptions before correlation analysis was performed. A Shapiro Wilk test was used to test data for normality; further, bivariate scatterplots were created in SPSS for dependent and independent variable pairing to ensure the data were free of outliers and to examine data for linearity and homoscedasticity. Pearson product-moment correlation coefficients

were conducted to test for potential relationships between elementary teachers' receptivity, comprised of general attitude and behavior intentions (dependent variables), and perceived school and other types of support, perceived practicality, issues of concern associated with implementing integrated STEM education, and years of teaching experience (independent variables).

Table 21 presents means and standard deviations for the dependent variables and independent variables. The first three independent variables (perceived school and other types of support, survey items S16-S23; perceived practicality, S24-S29; issues of concern associated with implementing integrated STEM education, S30-S35), a seven-point Likert-type scale was used. Participants specified whether they: disagree very strongly, disagree strongly, disagree, are neutral, agree, agree strongly, or agree very strongly. For the last independent variable (years of certified teaching experience), teachers were asked to report the number of years of certified teaching experience they had as part of the demographic data collection for the study. For continuity, a mean and standard deviation was provided for years of certified teaching experience. However, the number of years of participants' certified teaching experience was used to analyze for potential relationships with teachers' receptivity to integrated STEM education.

Table 21

Means and Standard Deviations for Teachers' Receptivity and Independent Variables (Sub-scales)

Variable	*N*	*Mean*	*SD*
Attitude[a]	181	5.11	1.1
Behavior Intentions[a]	181	4.88	.95
Perceived Support[b]	181	4.49	1.0
Perceived Practicality[b]	181	4.86	1.0
Issues of Concern[b]	181	3.94	1.1
Teaching Experience[b]	181	9.4	6.0

Note. [a] = Dependent variables; [b] = Independent variables.

Means and standard deviations show that participants generally indicated positive receptivity to integrated STEM education in the elementary grades. Further, in general, elementary teachers perceived that there was support for implementing integrated STEM education by their teaching peers, administrators, and students' parents, and there was support in place for assistance should any be needed for implementing STEM education. Moreover, participants generally agreed that integrated STEM education was practical for implementing into the elementary grades. However, they still had concerns about implementing integrated STEM education into the elementary grades.

Pearson product-moment correlation coefficients were calculated to assess potential relationships between receptivity (comprised of attitudes and behavior intentions) and perceived school support, perceived practicality, issues of concern, and years of certified teaching experience. Analysis was conducted on every dependent and

independent variable pairing. Below, see Figure 2 for a better understanding of correlation analyses performed.

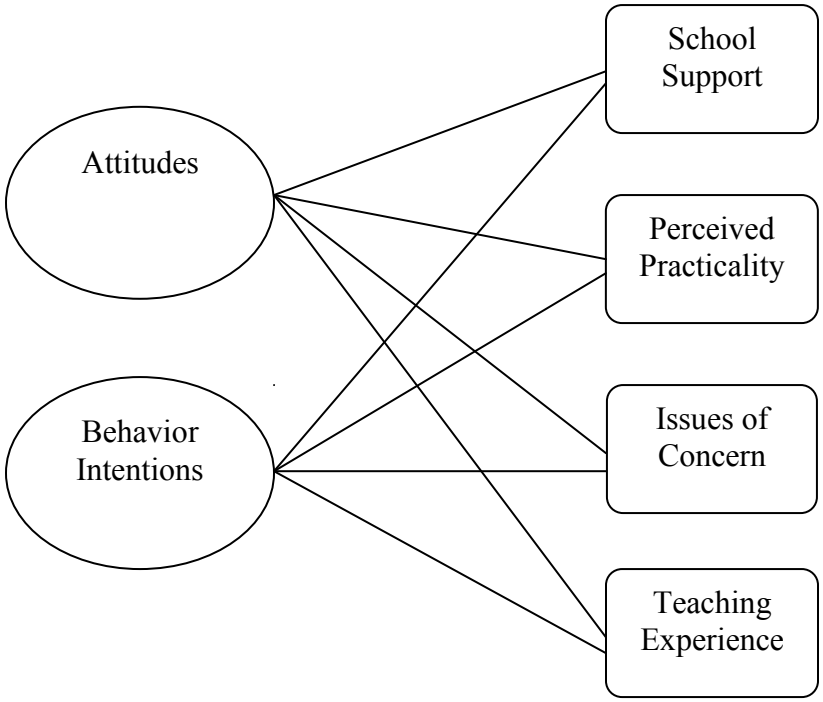


Figure 2. Each dependent variable was statistically compared with each independent variable. As a consequence, a total of eight pair-wise Pearson product-moment correlations were performed.

See Table 22 for correlation analyses results.

Table 22

Pearson Product Moment Correlation Coefficients Among Attitude and Behavior Intentions and Perceived School Support, Perceived Practicality, Issues of Concern, and Teaching Experience.

Dependent Variables		Independent Variables: School Support	Perceived Practicality	Issues of Concern	Teaching Experience
Attitude	Pearson's *r*	.510	.626	-.463	.057
	p	< .001***	< .001***	< .001***	.446
	N	181	181	181	181
Behavior Intentions	Pearson's *r*	.601	.702	-.563	.006
	p	< .001***	< .001***	< .001***	.932
	N	181	181	181	181

Note. ***p < .001

Pearson moment correlation coefficients revealed strong positive relationships between:

- Attitude and perceived school support $r(179)$ .51, p <.001
- Attitude and perceived practicality $r(179)$ .62, p <.001
- Behavior intentions and perceived school support $r(179)$ .60, $p < .001$
- Behavior intentions and perceived practicality $r(179)$ .70, $p < .001$

Overall, there was a strong positive relationship between attitude and perceived school support and attitude and perceived practicality. Higher attitude index ratings for integrated STEM education were strongly correlated with higher perceived school support ratings for implementing integrated STEM education. Moreover, higher attitude

index ratings for integrated STEM education were strongly correlated with higher perceived practicality of implementing integrated STEM education in the elementary grades.

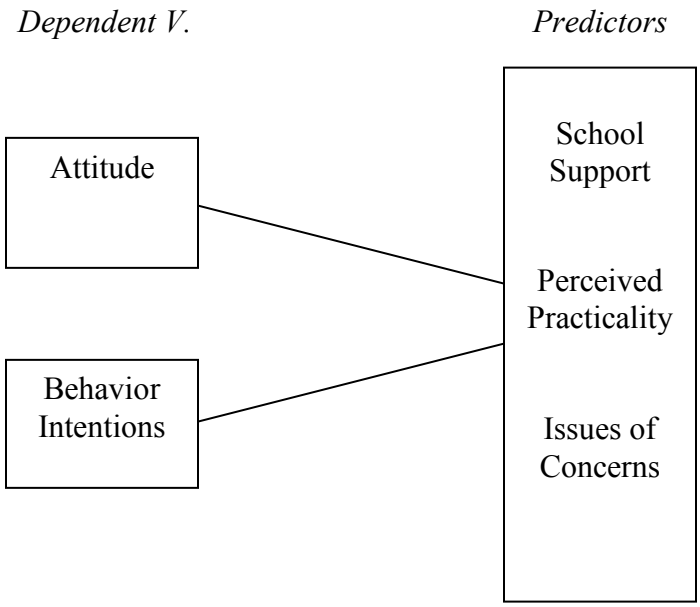
Overall, there was a strong positive relationship between behavior intentions and perceived school support and behavior intentions and perceived practicality. Higher behavior intentions index ratings for implementing integrated STEM education were strongly correlated with higher perceived school support ratings for implementing integrated STEM education. In addition, higher behavior intentions index ratings for implementing integrated STEM education were strongly correlated with higher perceived practicality of implementing integrated STEM education in the elementary grades. Pearson moment correlation coefficients indicated a medium and a strong negative relationship between:

- Attitude and issues of concern $r(179)$ -.46, $p < .001$
- Behavior intentions and issues of concern $r(179)$, -.56, $p < .001$

Overall, there was a medium negative relationship between attitude and issues of concern. Lower attitude index ratings to integrated STEM education were correlated with higher issues of concern index ratings toward implementing integrated STEM education into the elementary grades. Similarly, a strong negative relationship between behavior intentions and issues of concern was revealed. Lower behavior intentions ratings to implementing integrated STEM education correlated with higher issues of concern for implementing integrated STEM education into elementary education.

Finally, correlation analyses revealed that there was no relationship between attitude and certified teaching experience $r(179), .05, p = .44$, and behavior intentions and certified teaching experience $r(179), .006, p = .95$.

Multiple regression analysis was conducted to see how well the linear combination of the independent variables predicted teachers' general attitudes and behavior intentions. Independent variables included: (a) issues of concern associated with implementing integrated STEM education, (b) perceived school and other types of support, and (c) perceived practicality of integrated STEM education in the elementary grades. Teaching experience was omitted from the regression analysis because correlation analysis revealed that there was no relationship between attitude and certified teaching experience $r(179), .05, p = .44$, and behavior intentions and certified teaching experience $r(179), .006, p = .95$. See Figure 3 for a better understanding of the analyses performed.



Multiple Linear Regressions

Figure 3 shows the linear regression analyses: Receptivity (attitudes and behavior intentions) by the linear combination of perceived school and other support, perceived practicality, issues of concern.

A Shapiro-Wilk test showed that the data met the assumption of normality. Further, scatterplots for each dependent and independent variable pairing showed the data were free of outliers and met the assumptions of linearity and homoscedasticity. Finally, collinearity statistics were checked to test for multicollinearity among independent variables. The results showed that tolerance = .35 (lowest) and the variance inflation factor (VIF) = 2.1 (lowest; none exceeded 2.8), indicating the absence of multicollinearity between the independent variables. Table 23 provides the results for regression analysis.

Table 23

Multiple Regression Analysis of Receptivity by the Linear Combination of Predictors

Independent Variables (predictors)	Dependent Variables							
	Attitudes				Behavior Intentions			
	R Squared	Adjusted R Squared	B	β	R squared	Adjusted R Squared	B	β
	.40	.39			.51	.50		
School Support			.10	.09			.13	.14
Perceived Practicality			.61	.55***			.47	.52***
Issues of Concern			-.02	-.02			-.08	-.10

Note. Criterion variables included attitudes and behavior intentions. Predictor variables included perceived school support, perceived practicality, and issues of concern.

***$p < .001$

The result of a multiple linear regression model suggests that a significant proportion of the variation in participants' attitudes was predicted by a linear combination of issues of concern associated with implementing STEM education, perceived school and other types of support, and perceived practicality of integrated STEM education in the elementary grades, $F(3, 177) = 38.73$, $p < .001$. The sample multiple correlation coefficient was .63, indicating that 39.6% of the variance of the general attitudes index in the sample can be accounted for by issues of concern associated with implementing STEM education, perceived school and other types of support, and perceived practicality of integrated STEM education in the elementary grades. Bivariate correlations demonstrated that perceived school support and perceived practicality were positive and issues of concerns had an inverse relationship (negative), as expected. However, only perceived practicality was statistically significant ($p < .001$) to the prediction. Thus, the model predicts that for every 1 point increase on the perceived practicality index, general attitudes will increase by about .61 of a point holding all other independent variables constant.

The three independent variables are more powerful predictors of the participants' behavior intentions than of their attitudes. The result of a multiple linear regression model suggests that a significant proportion of the variation in teachers' behavior intentions was predicted by a linear combination of issues of concern associated with implementing integrated STEM education, perceived school and other types of support, and perceived practicality of integrated STEM education in the elementary grades, $F(3, 177) = 61.43$, $p < .001$. The sample multiple correlation coefficient was .71, indicating that 50% of the variance of the behavior intentions index in the sample can be accounted for by issues of

concern associated with implementing STEM education, perceived school and other types of support, and perceived practicality of integrated STEM education in the elementary grades. Bivariate correlations demonstrated that perceived school support and perceived practicality were positive and issues of concerns was negative, as expected. However, only perceived practicality was statistically significant ($p < .001$) to the prediction. Thus, the model predicts that for every 1 point increase on the perceived practicality index, behavior intentions will increase by about one-half (.47) point holding all other independent variables constant.

Research Question Four

Qualitative Data Analysis and Results. What are elementary teachers' perceptions toward the possible implementation of integrated STEM education in the elementary grades?

Following the quantitative phase of the study, eight interviews were conducted with elementary teacher volunteers who also participated in the survey. The qualitative phase of the study was designed to support, extend, and explain the quantitative results. Interviews were semi-structured, which enabled the researcher to ask follow-up questions for clarification and elaboration. All interviews took place at the interviewee's school, inside his/her classroom, and took approximately 20-30 minutes to complete. All interviewees were emailed the questions, along with a definition of integrated STEM education (see Appendix D), at least two days prior to their scheduled interviews. Table 24 presents demographic data for the teachers who participated in follow-up interviews.

Table 24

Demographic Data of Teachers Who Participated in Follow-up Interviews

Participant	Teaching Experience	Grade Level Assignment	Teaching Assignment	School Title 1 Eligibility	School STAR Rating
Teacher A	Novice (7)	Primary (K)	General Ed.	Title 1	2
Teacher B	Veteran (15)	Primary (1st)	General Ed.	Title 1	2
Teacher C	Veteran (9)	Primary (1st)	General Ed.	Title 1	2
Teacher D	Veteran (13)	Intermediate (6th)	General Ed.	Title 1	3
Teacher E	Novice (6)	Intermediate (5th)	General Ed.	Title 1	3
Teacher F	Novice (7)	Primary (3rd)	General Ed.	Title 1	3
Teacher G	Novice (3)	Intermediate (4th)	General Ed.	Title 1	3
Teacher H	Veteran (13)	Intermediate (4th)	General Ed.	Title 1	3

Note, that not all demographic subgroups were represented among these participants due to the low numbers that volunteered to be interviewed. However, five of the six of the original targeted subgroups were represented (i.e., novice and veteran teachers, primary and intermediate teachers, and teachers working in Title 1 schools). There is balance among the teaching experience and teaching grade level subgroups. Further, general education teachers, teachers working at Title 1 eligible schools, and teachers working at lower performing (2 STARs) and average performing schools (3 STARs) are represented in the sample. These teachers responded to five open-ended questions that sought their perceptions, insight, and concerns about the possible adoption and implementation of integrated STEM education in the elementary grades.

Interview question one. If your school were to implement integrated STEM education, what would your initial reaction be? What are your concerns or worries, if any?

Data were collected from each participant individually in a private location. The following represent themes that appeared among all or the majority of participants. Generally speaking, initial reactions were very positive. Teachers stated excitement primarily for their students. They had high regard for integrated STEM education and noted that STEM education would be good for students' achievement, dispositions, and providing opportunities for them to participate in activities that mirror what professionals in the STEM fields do. One teacher stated, "Bring it on." Another was not so sure, though. The initial reaction was that it would be one more thing "they" push down the line. However, this teacher was supportive toward integrated STEM education but was leery about how it would be implemented. Teachers did have concerns and worries. They reported that implementation of integrated STEM education would take time and that initial and continued support would have to be in place for successful transition of integrated STEM education into the elementary grades. The following are examples of concerns and worries that individuals or a minority of teachers in the sample possess:

- "Would STEM education be at an appropriate developmental level for kindergarten?"
- "How do I prepare?"
- "What is going to be different from what I already do?"
- "What am I going to need to look at and prepare for from an educational standpoint, a professional development standpoint?"

- "I am not quite sure what STEM education actually is and what it looks like. We get thrown into so many different things… It is the unknown that you really don't know where to go. I will be worried if I had no idea where to start; it would make it that much more of a challenge. A lot of times we are given stuff, and we are asked to do something with it. That is the hardest part, and the frustration is not knowing where to go with a new program."
- "My worries and concerns would be more on the engineering part… How can we get a hands-on engineering component into this? Another concern is how the school would support the technology so that we have enough technology for each student in the classrooms."
- "What are the objectives and how do teachers achieve those objectives?"
- "Will there be a curriculum? I hope that teachers will not be thrown in and be expected to develop a curriculum."

Interview question two. From your point of view, what are the potential benefits, if any, to implementing integrated STEM education in the elementary grades?

Overall, teachers agreed that integrated STEM education would provide students with opportunities they otherwise would not get. Exposure to science and technology was suggested as an exceptional benefit of integrated STEM education. The majority of the teachers stated that this would improve students' skill set that mirrors the attributes needed in higher education and the workforce (i.e., problem solving, cooperative problem solving, proficiency with technology, and reading and comprehending expository text). Some suggested that STEM education would better prepare students to compete in the 21st-century workforce. Further, it was agreed that integrated STEM education would

provide exposure to and insight into the sciences and occupations therein. As a consequence, this would inform and improve students' knowledge about the world. One teacher said that STEM education would give students a jumpstart should they want to pursue a STEM career. Other notable benefits expressed by individuals or a minority of teachers include:

- "STEM education will allow for students (future employees) to be globally competitive."
- Integrated STEM education, "improves students' persistence due to the problem solving focus."
- "Integrations of math and science will allow for students to see why math is important."
- "In our school, because we are a Title 1 school, half of my class does not have internet access at home. If we did implement STEM education, they would get that access to the internet on a regular basis. Then they could learn how to use the internet to search and to distinguish good from poor resources."

Interview question three. From your point of view, what are some potential obstacles, if any, to implementing integrated STEM education in the elementary grades?

Three main themes arose as perceived obstacles to implementing integrated STEM education. First, many of the teachers thought it would be a stretch to fully implement STEM education into the K-2 grade levels. One teacher stated:

> One obstacle would be in K-2 grade levels to try to get all that early literacy in along with STEM education. K-2 students must possess the early literacy building blocks, and I don't think you can decrease the time spent on word study, phonics,

> decoding, and figuring out what letters and numbers mean. These are essential building blocks to early literacy, which consume the time we currently have with students. However, because students have had the opportunity to build the basic literacy skills by grade three, I think starting there would be a better fit.

Second, interviewees reported that time might be an obstacle to implementing integrated STEM education. If implemented in haste, most felt that implementation would fail. One teacher expressed that they (the school district) would have to implement integrated STEM education similar to how the Common Core State Standards (CCSS) were implemented—measured gradually over a multiple-year time span. Further, the implementation plan would have to be well organized and thought out. Time would have to be given for professional development and content training. Some suggested that this would improve teacher buy-in. Moreover, accountability for the implementation would have to be in place. Teachers would have to be informed of teacher and student expectations, curriculum standards, and grade-level and overall objectives. In addition, time in professional learning communities (PLCs) would be necessary for grade-level and vertical alignment so that all teachers would be on the same page.

Finally, teachers identified financial obstacles to implementing integrated STEM education. With recent budget cuts, teachers expressed concerns that providing the curriculum and technology necessary for successful implementation of STEM education may be an obstacle. It would be difficult to maintain even the basic supplies that would be needed in every classroom for STEM project-based learning, particularly for some of the engineering projects. Many perceived obstacles for future budgeting to repair and to replace antiquated technology.

Interview question four. Generally speaking, do you believe there would be support for implementing integrated STEM education in your school by your colleagues? by your administrators?

Most agreed that over 50% of staff (certified and classified staff) would support implementing integrated STEM education into the elementary grades. One teacher suggested that the percentage would be right at about 50% (half would support and half would resist the change). None of the teacher interview participants projected that the majority of teachers and interventionists at their schools would not support implementing integrated STEM education into the elementary grades. Again, they suggested support would be contingent on appropriate training, time for transition, curriculum, supplies, and continued support. However, it was expressed that there would be some general personal transitional insecurities due to the change (i.e., content and pedagogical knowledge, understanding expectations, standards, and objectives), but they claimed that teachers would likely receive integrated STEM education well overall. As far as administrators' support, several of the teachers in the sample suggested that administrators would be on board, whereas another stated that their administrator(s) might reserve judgment until they observed school achievement stability. The remaining interviewees suggested that they were unsure because their administrators were new to the school and they did not know them well enough to infer their views on implementing integrated STEM education.

Interview question five. What other perspectives would you offer concerning the implementation of integrated STEM education that I have not asked?

As expected, this question provided the most varied answers among interview participants. Much of the participants' perspectives were related to addressing and ensuring that the aforementioned obstacles were thought through, tested, and problems addressed prior to implementing integrated STEM education into the elementary grades. Teachers in this sample thought that professors (STEM and teacher educators) and STEM professionals should have a part in implementing integrated STEM education into the elementary grades. These professionals, it was proposed, could come into the classrooms to talk to students and share their insight, expertise, and passion for their professions. Further, professors and STEM professionals could provide workshops and trainings for teachers and out-of-school programs for students. Moreover, professors and other stakeholders could assist in providing data necessary to ensure that any intended outcomes of implementing integrated STEM education in the elementary grades can actually meet those objectives. Finally, it was recommended that implementation specialists investigate what is already being done in classrooms to find alignment between old and new curriculum and pedagogical practices. This way, it was suggested, it might be found that many teachers are already doing many of the things that will be expected in the new curriculum and thus transition can be less difficult due to pointing out these associations between what is being done and new expectations.

Related to this, another teacher advised that schools not be seen as cookie cutter. The teacher stated, "Elementary schools can be very different from one another based on variables that teachers and administrators have little to no control over. STEM education may be awesome in one place but may not work in another because of the lack of parental support and personal desire to persevere. In some cases, teachers can overcome

these obstacles but you see the most success when the teacher and parents are collectively providing that push. If you don't have those pieces together, one pushing and the other pulling then it will be like a piece of spaghetti; without one pushing and one pulling, the spaghetti will bunch up and you don't get as far as expected".

Several teachers added that a definition of integrated STEM education should be in place that addresses the district's (secondary, middle, and elementary) purpose, standards, and intended outcomes. Another added, to bring this to fruition, a committee of informed stakeholders (i.e., teachers, administrators, parents, professionals, professors, and business leaders) could be charged with the task of developing a definition for STEM education.

One teacher provided perspective on what can be done at the university level by professors to assist preparing pre-service and in-service teachers to implement and teach integrated STEM education presently and in the future:

> One of the biggest things that I think colleges can do is to use better instructional strategies to model for their students, especially pre-service teachers, what good teaching looks like in the classroom. Many pre-service teachers come in and want to be the sage on the stage when we need to be coaching and facilitating our students. We tend to teach the way we were taught, and in my experience, professors like being the sage on the stage and often lecture the majority of class time. If the next generation of teachers are to be prepared to teach STEM education, professors need to use and model the strategies they expect their pre-service teachers to use during instruction.

Summary

Research question one. What is elementary teachers' degree of receptivity to implementing integrated STEM education in the elementary grades?

Certified elementary teachers' overall average on the general attitude scale index was $M = 5.11$, $SD = 1.1$ and on the behavior intentions scale index $M = 4.88$, $SD = .95$ to implementing integrated STEM education into the elementary grades. Both the attitude and behavior intentions overall averages are greater than the scale neutral score of 4.0, which indicates overall positive attitude and behavior intentions (receptivity) by elementary teachers to integrated STEM education in the elementary grades.

Research question two. What differences, if any, exist among elementary teacher subgroups in receptivity to implementing integrated STEM education in the elementary grades?

Independent t, Mann-Whitney U, and one-way analysis of variance tests were used to answer research question two. Novice teachers had significantly more positive attitudes than veteran teachers to integrated STEM education in the elementary school. Behavior intentions did not differ between novice and veteran teachers. Analyses revealed that general education teachers had significantly higher (more positive) attitudes and behavior intentions toward integrated STEM education in the elementary grades than did special education teachers. However, there were no differences in attitude and behavior intentions between general education teachers and ESL education teachers. Moreover, there were no differences in attitude and behavior intention between special education teachers and ESL education teachers. Further, it was revealed that there was no difference in attitude between primary and intermediate teachers. However, intermediate

teachers had significantly more positive behavior intentions than primary teachers. Moreover, it was revealed that there was not a difference in attitude or behavior intentions by teachers working in Title 1 schools and teachers working in Title 1 ineligible schools. Finally, analyses revealed that there was no difference in attitude and behavior intentions by teachers working in 1-2, 3, or 4-5 STAR-rated schools.

Research question three. What relationships, if any, exist between elementary teachers' receptivity and teachers' issues of concern associated with implementing integrated STEM education in the elementary grades, perceived school and other types of support, perceived practicality of implementing integrated STEM education in the elementary grades, and years of certified teaching experience?

Correlation analyses revealed strong positive relationships between teachers' attitude and their perceived school support, teachers' attitude and their perceived practicality, teachers' behavior intentions and their perceived school support, and teachers' behavior intentions and their perceived practicality. Moreover, strong negative relationships were revealed between teachers' attitude and their issues of concern, and teachers' behavior intentions and their issues of concern. Conversely, correlation analyses revealed that there was no relationship between teachers' attitude and years of certified teaching experience, and between teachers' behavior intentions and years of certified teaching experience.

Multiple linear regression revealed that a significant proportion of the variation in teachers' attitudes and teachers' behavior intentions was predicted by the linear combination of teachers' issues of concern associated with implementing STEM education, perceived school and other types of support, and perceived practicality of

integrated STEM education in the elementary grades. In addition, teachers' perceived practicality (which accounted for most of the variance) was a significant predictor of teachers' attitudes and behavior intentions toward integrated STEM education in the elementary grades.

Research question four. What are elementary teachers' perceptions toward the possible implementation of integrated STEM education in the elementary grades?

Elementary teachers who participated in interviews showed initial positive reactions to implementing integrated STEM education in the elementary grades. However, participants identified obstacles that would have to be addressed before successful implementation could take place. Overall, it was acknowledged that school staff and administrators would support implementation of integrated STEM education in the elementary grades. Finally, participants offered perspectives on how best to achieve transitioning integrated STEM education into the elementary grades.

Chapter five offers a summary of the study, discussion of findings, implications for practice, recommendations for further research, and conclusions.

Chapter Five

Summary, Discussion, and Conclusions

In chapter four, analyses and results of the study were reported. Chapter five includes a summary of the study, discussion of findings, implications for practice, recommendations for further research, and conclusions.

The purpose of this study was to investigate elementary teachers' receptivity (general attitudes and behavioral intentions) to integrated STEM education prior to formal approval and declaration of its implementation in elementary schools. Further, this study explored potential differences in elementary teachers' receptivity among subgroups, which were determined by personal and school demographic subgroups (i.e., assigned grade level, type of teaching assignment, completed years of certified school teaching experience, school Title I eligibility, and school STAR-performance rating). Next, the study included examination of the relationships between elementary teachers' receptivity to integrated STEM education and teachers' issues of concern associated with implementing integrated STEM education, perceived school and other types of support, perceived practicality of integrated STEM education in the elementary grades, and years of certified teaching experience. The study further looked at the predictability of the linear combination of the first three independent variables on each of the dependent variables. Finally, the researcher conducted eight interviews with elementary teachers to ascertain their perspectives, insights, and concerns regarding the implementation of integrated STEM education into the elementary grades.

The survey instrument (Appendix A) was formatted and uploaded to SurveyMonkey; this online software allowed the researcher to post and participants to

take the survey online. Participants (n = 181) completed a 35-item, seven-point Likert-type survey instrument, which was adapted from Waugh and Godfrey's (1993,1995) receptivity to change instruments, and Lee's (2000) receptivity to change instrument, which was also adapted from Waugh and Godfrey's (1993) original receptivity to change instrument (Lee, 2000). Semi-structured interviews were conducted with survey participants who volunteered to be interviewed. Eight participants volunteered for a follow-up interview and all were interviewed. Participants represented five of the six targeted demographic subgroups that were also used, in part, to examine differences in teachers' receptivity (i.e., works at a Title 1 eligible school; teaching experience, novice or veteran; and current grade-level assignment, primary or intermediate). Qualitative data were used to support quantitative data; it was summarized by themes that appeared among a majority of participants and organized by the five interview questions (Appendix D). Further, the basis of this study is comprised of four research questions:

Quantitative

1. What is elementary teachers' degree of receptivity to implementing integrated STEM education in the elementary grades?
2. What differences, if any, exist among selected elementary teacher subgroups in receptivity to implementing integrated STEM education in the elementary grades?
3. What relationships, if any, exist between elementary teachers' receptivity and issues of concern associated with implementing integrated STEM education in the elementary grades, perceived school and other types of support, perceived practicality of implementing integrated STEM education in the elementary grades, and years of teaching experience?

Qualitative

4. What are elementary teachers' perceptions toward the possible implementation of integrated STEM education in the elementary grades?

Questions one through three were answered quantitatively using the data obtained from the online survey. Question one was answered using the results from descriptive statistics. To answer question two, the results from independent t-tests, Mann-Whitney U, and one-way analysis of variance (ANOVA) were used to identify potential differences in independent sample means among the following subgroups: (a) grade-level assignment, primary, intermediate, (b) teaching assignment, general education, special education, or ESL education, (c) teaching experience, novice or veteran, (d) school Title 1 eligibility, eligible or ineligible, (e) school STAR performance ratings, 1-2 STAR(s), 3 STARs, or 4-5 STARs.

For Question three, Pearson product moment correlations provided the analysis to answer what relationships, if any, exist between elementary teachers' receptivity (comprised of two dependent variables, general attitudes and behavior intentions) and issues of concern associated with implementing integrated STEM education in the elementary grades, perceived school and other types of support, perceived practicality of implementing integrated STEM education in the elementary grades, and years of teaching experience. In addition, multiple linear regression was used to answer whether teachers' general attitudes and teachers' behavior intentions (receptivity) toward integrated STEM education could be predicted by the linear combination of issues of concern associated with implementing STEM education, perceived school and other types of support, and perceived practicality of integrated STEM education in the elementary grades. Certified

teaching experience was dropped as predictor because correlation analysis showed that there is no relationship with teachers' receptivity.

Question four (qualitative) was designed to support, extend, and explain the quantitative results. Eight participants responded to five open-ended interview questions pertaining to the implementation of integrated STEM education in the elementary grades. Qualitative data were analyzed according to Shank's (2006) recommendations. All interviews were audio recorded. Following each interview, the researcher transcribed the recorded data. Once all interviews were completed and transcribed, qualitative data were reviewed for themes that appeared across participants. Similar themes were assigned codes across participants and then organized into categories. Finally, categories were organized, summarized, and presented in the order that interview questions were asked.

Summary of Study Results

In general, descriptive statistics revealed that certified elementary teachers had positive attitude and behavior intentions toward integrated STEM education in the elementary grades. More than three-quarters (76.7%) of all participants reported positive attitudes and behavior intentions, while the remaining participants rated themselves as neutral, positive on attitude or behavior intentions only, and unreceptive toward integrated STEM education in the elementary grades. Overall, participants tended to have more positive attitudes than behavior intentions to integrated STEM education in the elementary grades. One teacher, during an interview, may have indirectly provided some insight as to why this difference occurred. She suggested that others (teachers and administrators) may reserve judgments toward integrated STEM education until it proves to produce the desired results. It seems that elementary teachers were excited but have

some reservations about integrated STEM education and thus may reserve overdoing verbal praise and support of likely actions (behavior intentions) until integrated STEM education provides evidence that students' achievement scores will improve in the elementary grades.

Analysis showed receptivity differences among personal demographic subgroups, but not school demographics subgroups. Experience made a difference. Novice teachers had significantly more positive attitudes than veteran teachers to integrated STEM education, but behavior intentions did not differ among novice and veteran teachers. General education teachers had significantly more favorable attitudes and behavior intentions than did special education teachers. However, there were no differences in attitude and behavior intentions between general education teachers and ESL education teachers, and there were no differences in attitude and behavior intentions between special education teachers and ESL education teachers. Finally, primary and intermediate teachers did not differ in attitude. However, intermediate teachers proved to have significantly more positive behavior intentions toward integrated STEM education than did their primary-grades peers.

Correlation analyses showed strong positive relationships between participants' attitude and their perceived school support, participants' attitude and perceived practicality, participants' behavior intentions and their perceived school support, and participants' behavior intentions and perceived practicality. Moreover, strong negative relationships appeared between participants' attitude and their issues of concern, and teachers' behavior intentions and their issues of concern. Conversely, correlation analysis showed that relationships did not exist between participants' attitude and years of

certified teaching experience, and between participants' behavior intentions and years of certified teaching experience.

Multiple linear regression analysis showed that a significant proportion of the variation in teachers' attitude and teachers' behavior intentions was predicted by a linear combination of issues of concern associated with implementing STEM education, perceived school and other types of support, and perceived practicality of integrated STEM education in the elementary grades. In addition, teachers' perceived practicality (which accounted for most of the variance) was a significant predictor of teachers' attitudes and teachers' behavior intentions toward integrated STEM education in the elementary grades.

Interviews with teachers confirmed that they are on board and excited about integrated STEM education in the elementary grades. The majority of these participants reported that they have positive initial reactions to implementing integrated STEM education. Although open to integrated STEM education, teachers cautioned that there may be obstacles and that many would have to be addressed before implementation could take place successfully. Overall, it was agreed that school staff and administrators would support the implementation of integrated STEM education into the elementary grades. Some of the most prevalent potential obstacles identified by teachers were that there needed to be initial curriculum, transition, and professional development support. Further, there would need to be continued financial support, stakeholder collaboration, and time designated for grade-level and vertical alignment collaboration among general, resource, and intervention teachers. Other suggestions included putting together a team of

educators to define integrated STEM education as it applies to elementary schools and to outline explicit teacher and student objectives and expectations for each grade level.

Discussion of the Findings

The National Science Board (2007) has recognized that it will take the combined efforts of all those that will influence the results of developing, initiating, implementing, and improving integrated STEM education in the United States. It is no surprise that teachers will play a significant role in this process. In fact, research has shown that teachers' receptivity to educational reform is a strong indicator for influencing successful or unsuccessful outcomes (Waugh, 2000; Yin & Lee, 2008). The primary objective of this study was to understand certified elementary teachers' receptivity to integrated STEM education prior to a formal proposal and implementation of it into the elementary grades. Second, the study sought to answer whether there were differences among teachers based on personal and school demographics. Third, the study investigated relationships between dependent and independent variables and whether the linear combination of three independent variables could be a predictor model for teachers' attitude and teachers' behavior intentions (attitude and behavior intentions treated as separate criterion variables). Finally, the study sought volunteer teachers to expound upon their perspectives, insight, and concerns associated with implementing integrated STEM education in face-to-face interviews.

Research question one. What is elementary teachers' degree of receptivity to implementing integrated STEM education in the elementary grades?

The results concluded that elementary teachers in this study had positive receptivity to integrated STEM education (M = 5.11, SD = 1.1) and behavior intentions (M = 4.88, SD = .95). Further, a strong majority (76.7%) of the participants indicated that they were receptive, while 1.1% were neutral, and 12.2% were unfavorable toward integrated STEM education. The remaining 10% were positive on one scale index but not the other, which can be categorized as unreceptive as well. Thus, positive receptivity of teachers in this study proved to be good news considering the current advocacy for integrated STEM education in the elementary grades (Brenner, 2009; Bybee & Fuchs, 2006; DeJarnette, 2012) and the implications that teachers' positive receptivity have for successful outcomes of educational reform (Waugh, 2000). Waugh and Godfrey (1993) state:

> In any major educational change which involves teaching in the classroom, the attitudes and behavior of the teachers who have to implement the change, and particularly the strength of their receptivity to the change, are important determinants of the success of the implementation of that change (p. 7).

This study provides evidence that elementary teachers appear to be receptive to integrated STEM education in the elementary grades if reform were to be advocated, mandated, and implemented. Due to teachers' positive receptivity and the assumption that teachers' needs are met, a successful outcome for implementing integrated STEM education into the elementary grades is more likely to occur.

Research question two. What differences, if any, exist among selected elementary teacher subgroups in receptivity to implementing integrated STEM education in the elementary grades?

As with any major educational reform, students and teachers will often be the most influenced by curriculum change; therefore, their receptivity will greatly determine the success or failure of its implementation (Ha, Wong, Sum, & Chan, 2008; Lee et al., 2011; Waugh, 2000).

However, not all teachers will have the same receptivity to educational change. Thus, it is important to assess differences among personal demographic and school demographic subgroups. This understanding may provide insight into those groups that are receptive and those that are less receptive than their peers or possibly unreceptive to integrated STEM education. Understanding of differences can pinpoint possible subgroups that might have more reservations and thus might have more needs that will need to be met before they are on board with integrated STEM education. Meeting teachers' needs in various subgroups may improve teachers' attitudes and teachers' behavior intentions regardless of their current receptivity to integrated STEM education in the elementary grades.

Analysis revealed that novice teachers had significantly more positive attitudes than did veteran teachers to integrated STEM education, but behavior intentions among these two groups did not differ. Hargreaves (2005) found that teachers with less experience were often more accepting of change. This might be because new teachers have less time invested in developing their teaching beliefs and pedagogical craft. Conversely, experienced teachers have had the time to invest substantially in developing

their beliefs and teaching craft and might find it more difficult to accept educational reform. Ma, Yin, Tang, and Liu (2009) found similar results concerning teachers' attitudes toward educational change in their receptivity study. However, their study categorized teaching experience into four ranges of years teaching: 1-3, 4-10, 11-20, and 21-30 years. Teachers with 10 years or less of teaching experience had more positive attitudes toward curriculum change than those with 11 years or more. Concerning teachers' behavior intentions, Ma et al.'s (2009) study showed that less experienced teachers had significantly more positive behavior intentions toward curriculum change, which differed from this study's findings.

The statistical analyses showed that general education teachers had significantly more favorable attitudes and behavior intentions toward integrated STEM education in the elementary grades than did special education teachers. However, there were no differences in attitude and behavior intentions between general education teachers and ESL education teachers and between special education teachers and ESL education teachers. It should be noted that there was a relatively low number of ESL teacher participants (n = 10) in the sample, which may have influenced the lack of difference in attitudes and behavior intentions between general education and ESL education teachers.

One reason for the difference in attitude and behavior intentions between general and special education teachers may be that special education teachers had more issues of concern with integrated STEM education than did general educators. Some of these included concerns that integrated STEM education would take away student learning time for mathematics, literacy, and social studies, classroom management issues may arise due to the implementation and the everyday use of STEM curriculum, and

uncertainty that they (teachers) possessed appropriate and sufficient content knowledge in one or more content areas emphasized by STEM curricula. Correlation analysis in this study and other receptivity studies (Lee, 2000; Ma et al., 2009) revealed that teachers with less favorable attitudes and behavior intentions had significant negative relationships with issues of concern toward the educational reform. In this study, special education teachers had higher issues of concerns than did general education teachers with integrated STEM education, which may explain their significantly lower attitude and behavior intentions.

Statistical analysis revealed that there was no difference in attitude by primary and intermediate teachers. However, there was a significant difference in behavior intentions. One reason might be that primary teachers might have less positive attitudes than what was designated on the attitude scale. Primary teachers interviewed made it clear that STEM curriculum would have to be grade-level appropriate for their grade level. Some stated apprehension with squeezing integrated STEM education in with all that is already necessary for early literacy development. Conversely, intermediate teachers showed less apprehension toward integrated STEM education and thus they have more positive behavior intentions. Interview data indicated that intermediate teachers had less apprehension about whether integrated STEM education would be grade-level appropriate than did teachers in the primary grades.

Finally, school subgroups showed no differences in receptivity. There were no differences in attitude or behavior intention by teachers working in Title 1 schools and teachers working in Title 1 ineligible schools, and there were no differences in attitude and behavior intentions by teachers working 1-2, 3, or 4-5 STAR-rated schools. School

demographic subgroups seemed to have little bearing on teachers' receptivity to integrated STEM education. However, it was revealed that teachers working at 3 STAR-rated schools had the highest mean scores in teachers' attitude and teachers' behavior intentions and teachers working at 1-2 STAR-rated schools had the lowest. One teacher provided some insight into why teachers working in 1-2 STAR-rated (lower-performing) schools have the lowest mean score in receptivity. It was stated that teachers working in lower-performing schools are under a lot of pressure to improve literacy and mathematics achievement scores to meet annual yearly progress (AYP). The teacher expressed concern that learning and implementing STEM education may slow or impede current progress that is taking place in her school. It was suggested that STEM education may be more appropriate for implementation when the school was able to move up to a 3-STAR rating. Once this occurred some of the pressure would be off the teachers and administration and more time would be available to implement a new program.

Research question three. What relationships, if any, exist between elementary teachers' receptivity and potential concerns associated with implementing integrated STEM education in the elementary grades, perceived school and other types of support, perceived practicality of implementing integrated STEM education in the elementary grades, and years of teaching experience?

Correlation analyses showed strong positive relationships between teachers' attitude and their perceived school support, teachers' attitude and perceived practicality, teachers' behavior intentions and their perceived school support, and teachers' behavior intentions and perceived practicality. Moreover, strong negative relationships appeared between teachers' attitudes and their issues of concern, and teachers' behavior intentions

and their issues of concern. Conversely, correlation analysis showed that relationships did not exist between elementary teachers' attitudes and years of certified teaching experience, and between elementary teachers' behavior intentions and years of certified teaching experience.

This study supports previous literature regarding receptivity to curriculum reform, which has shown similar relationships between teachers' attitudes and teachers' behavior intentions with various independent variables. Lee (2000) found that there were relationships between teachers' attitudes and teachers' behavior intentions and (a) perceived non-monetary costs (return and workload), (b) perceived practicality, (c) issues of concern, (d) perceived school support, and (e) perceived other support. In addition, Ma et al. (2009) found relationships between teachers' general attitudes and teachers' behavior intentions and (a) preparation for reform (curriculum and ease of use and implementation), (b) perceived practicality, (c) cost-benefit (return and workload), and (d) issues of concern. This study supports both Lee's (2000) and Ma et al.'s (2009) findings that a relationship exists between teachers' attitudes and teachers' behavior intentions and their perceived practicality and issues of concern regarding educational reform. In addition, this study supports Lee's (2000) finding that a relationship exists between teachers' attitudes and teachers' behavior intentions and their perceived school and other support for implementing educational reform.

Further, the linear combination of issues of concern associated with implementing STEM education, perceived school and other types of support, and perceived practicality of integrated STEM education in the elementary grades is a significant predictor model for teachers' attitudes and teachers' behavior intentions. However, the majority of the

variance is attributed to teachers' perceived practicality of integrated STEM education, which was the only significant individual predictor of each of the dependent variables. Although they analyzed different predictors, Moroz and Waugh (2000) found that the linear combination of four independent variables (alleviation of fears and concerns, non-monetary cost benefits, significant other support, and feelings compared to the previous system) was a significant predictor model for teachers' attitudes and teachers' behavior intentions and other dependent variables used in their study.

Isolating individual predictors, this study supports Lee's (2000) finding that teachers' perceived practicality of educational reform was a significant predictor of teachers' attitudes and teachers' behavior intentions, and Ma et al.'s (2009) findings that teachers' perceived practicality was a significant predictor for teachers' behavior intentions. However, Lee (2000) and Ma et al. (2009) found that issues of concern was also a significant predictor of teachers' attitudes and teachers' behavior intentions, which is different than the findings of this study. Moreover, Lee (2000) also found perceived school and other support to be significant predictors (school and other support are separate independent variables in Lee's study) of teachers' attitudes and teachers' behavior intentions, which, again, is different than the findings of this study. The relatively low (n =181) sample size in this study (compared to Lee's n = 1,687; and Ma's et al.'s n = 763) may have contributed to these contradictions.

Research question four. What are elementary teachers' perceptions toward the possible implementation of integrated STEM education in the elementary grades?

Sitting down and talking with teachers provided insight that would have otherwise been missed. Overall, the elementary teachers in this study showed positive receptivity to

integrated STEM education. Initial reactions were of cautious enthusiasm. Although open to integrated STEM education, teachers were adamant that many obstacles would have to be addressed before implementation could take place successfully. Most agreed that implementation of integrated STEM education into elementary grades would fail if it were to be dropped at their feet without adequate support (initial and continued), development, and mutual accountability. Meeting teachers' needs and giving them the support, freedom, and time to make decisions about how to best implement integrated STEM education curriculum may go a long way toward ensuring that the transition will be successful in the elementary grades. Mayo (1933) asserted that meeting workers' needs to feel valued, secure, and part of a cooperative working team can contribute to improved output within an organization.

A collaborative approach will be necessary to accomplish a successful outcome for implementing integrated STEM education into the elementary grades. The teachers in this research agreed that their roles would be vital and thus they would have to have time to participate in professional development to learn curriculum, goals, expectations, objectives, and standards of integrated STEM education. Further, they advocated for grade-level and vertical alignment planning time with their grade-level partners and teaching peers. Roethlisberger and Dickson (1966) affirmed that one way to meet emotional needs is by recognizing that workers add value to the organization and have expertise and insight that may improve the overall working conditions and productivity of the workplace. Further, the teachers in this study expressed that all stakeholders (i.e., STEM educators, professionals, teacher educators, administrators, and teachers) would have to collaborate in order to improve instruction. Roethlisberger and Dickson (1966)

asserted that another way to meet the needs of the individual is recognizing that work is often a group activity; working in harmony, two is better than one when it comes to efficient output. Workers need to feel the sense that they are part of a community working together for a greater goal.

Participants expressed reservations about grade-level appropriateness of integrated STEM curriculum, especially in grades K-2. Time was another factor that concerned teachers. They expressed concern that integrated STEM education might consume time necessary for literacy and mathematics learning. Further, several acknowledged that the implementation of integrated STEM education would take time and that all stakeholders would have to be patient. One teacher stated that the implementation of STEM education should mirror how the Common Core State Standards were implemented and agreed that the timeframe (four years) used to implement the CCSS would be necessary to implement integrated STEM education in the elementary grades.

Theoretical Framework Revisited

Whyte (1956) described an environment incorporating human relations principles as having free-flowing lines of communication up and down the chain of command. Further, human relations theorists posit that workers are more than isolated functioning parts. Rather, they are viewed as valuable contributors within an organization with social and psychological needs that can result in improved organizational efficiency and productivity if acknowledged and attended to (AlMusaileem, 2012; Mordi & Idris, 2001; Roethlisberger & Dickson, 1966).

Not unlike other organizations, there is a need to meet the humanistic needs of teachers within school settings to increase productivity and efficiency. Bureaucratic top-down approaches in education can strangle buy-in and creativity, suppress valuable perspectives and insights, and inhibit cooperative interaction in the name of order, structure, and achievement. However, a democratic leadership approach utilizes the valuable human resources possessed within the school walls to assist in organizational decision-making (Gulcan, 2011; Mulkeen, Cambron-McCabe, & Anderson, 1994). It will take the combined efforts of all educators with a shared commitment to implementing integrated STEM education if change is to take place successfully.

The elementary teachers in this study indicated that they are receptive to implementing integrated STEM education in the elementary grades. However, they are cautious because they understand that there will be many barriers to successful implementation. AlMusaileem (2012) posits that human relations proponents have focused attention on highlighting the importance of organizational group-dynamics and the positive relationship that it has with productivity. Gulcan (2011) asserts that within an organization there is a need for workers to participate in organizational decision-making processes that influence policy changes that directly affect their working environments. Considering that teachers are in the classroom every day engaged with students, their perceived barriers to integrated STEM education can inform other stakeholders of impediments that may be otherwise unforeseen. Moreover, considering teachers' perspectives sincerely can meet the social and psychological needs of teachers, both of which can improve efficiency and productivity (AlMusaileem, 2012).

Implications for Teacher Education

Advocacy for improving and expanding the reach of integrated STEM education has been building for some time now. There is a sense of urgency to prepare students with the 21st-century skills they will need, many of which involve STEM, to be productive U.S. citizens qualified to compete with an increasingly dynamic international workforce (National Science Board, 2010). This study improves awareness to stakeholders with vested interests in, particularly teacher educators and educators, of national educational leanings toward the possible implementation of integrated STEM education in K-12 grades to better prepare students as part of a wider effort to meet national workforce needs.

In 2009, President Obama committed over four billion "Race to the Top" dollars to this national undertaking (Obama, 2009). Several years later he committed 3.1 billion dollars for STEM programs for the 2014 fiscal year (Obama, 2013). Of the 3.1 billion dollars, 814 million dollars of this funding is earmarked for K-12 education. Money will be invested with the intent to improve relationships between school districts and universities to build partnerships, to prepare 100,000 STEM-trained teachers, and to start a master teacher program where the best science and mathematics teachers are recruited to assist with improving instruction in their schools and districts. Moreover, money will be directed to redesign high schools to make them STEM-focused and to research dedicated to improving the teaching and learning of integrated STEM education.

The results of this study show that elementary teachers' attitudes and elementary teachers' behavioral intentions (receptivity) toward integrated STEM education in the elementary grades are positive. This is an important understanding considering what

research has indicated about the influence that teachers' receptivity can have on the successful and unsuccessful outcomes of educational reform. It is evident with the advocacy for and investment in integrated STEM education that there may be a time very soon where integrated STEM education is mandated for implementation in all public schools in some form. Therefore, this study has provided insight into how elementary teachers will receive integrated STEM education should it be mandated for implementation in the near future.

Moreover, this study found differences in teachers' receptivity by comparing personal demographic subgroups. This knowledge can assist in identifying and seeking out groups that have lower receptivity than their peers in order to address and meet their needs and concerns. Further, this study highlighted personal variables that have a significant relationship with elementary teachers' receptivity. Understanding variables that have a relationship with teachers' receptivity provides a starting place to address teachers' needs. For example, it was found that teachers' attitudes and behavior intentions had a strong negative relationship with teachers' issues of concern associated with implementing integrated STEM education. Therefore, understanding teachers' issues of concern can be a starting point for addressing those concerns, and addressing the concerns of teachers related to implementing STEM education can conceivably lower teachers' issues of concern. The resulting lower teachers' concerns may very well improve teachers' attitude and behavior intentions toward integrated STEM education, which in turn improves successful outcomes of reform (Ha, Wong, Sum, & Chan, 2008; Lee et al., 2011; Waugh, 2000).

The qualitative phase of the study was designed to support, extend, and explain the quantitative results. Elementary teachers in this study have high regard for integrated STEM education, and they perceive that the majority of the staff and administration working at their schools will be receptive to the implementation of integrated STEM education in the elementary grades. However, participants identified some obstacles that would have to be addressed before successful implementation could take place. In addition, teachers provided their perspectives related to easing transitions of integrated STEM education into the elementary grades. This information provides details from which to address elementary teachers' concerns, obstacles, and perspectives that if addressed can facilitate successful implementation of integrated STEM education into the elementary grades.

Implications for the field of integrated STEM education. This understanding may provide awareness for STEM educators regarding overall receptivity, receptivity differences, variables that have a relationship with receptivity, and the combination of variables that are predictors of teachers' receptivity to integrated STEM education. Further, this study can provide a starting point from which to develop other studies that initiate discourse with elementary teachers and other stakeholders regarding their valuable insights concerning integrated STEM education, which may augment its successful transition into elementary, secondary, and post-secondary grades. It is hoped that future studies, professional development efforts, and curriculum design can be adapted based on findings of this study—particularly the insights and concerns elementary teachers have provided to address potential barriers to successful implementation of integrated STEM education in the elementary grades.

Limitations of the Study

For the first part of the survey (attitude index), participants chose a rating response along a seven-category semantic differential (a variation of the Likert scale) that fell between adjective pairs representing opposite ends of an attitudinal spectrum (McMillan & Schumacher, 2006). The remaining survey items used a seven-point Likert scale. Participants specified whether they disagree very strongly, disagree strongly, disagree, are neutral, agree, agree strongly, or agree very strongly. On both the semantic differential and the Likert scale, participants had the opportunity to choose a neutral position. Many participants seemed to choose this rating. The survey instrument may have been stronger by omitting this position. This would have forced neutral hoverers to choose what side of the spectrum they leaned toward (i.e., disagree or agree), which may have provided more reliable data regarding participants' receptivity, perceptions, and issues of concern associated with integrated STEM education in the elementary grades.

Another limitation to this study was the season and timeframe that these data were collected. Data collection occurred during the holiday season. Further, the timeframe concluded as sufficient was three weeks to collect quantitative data and an additional week to collect qualitative data. Both of these decisions may have negatively affected the sample size. The holiday season is generally a hectic time for teachers. Teachers can feel a bit overwhelmed during this time, personally and professionally, which likely caused some teachers to be unable or unwilling to participate. In addition, three weeks was not a sufficient amount of time to collect data in this school district. Participants were added every day, including the last day the survey was open. I believe that leaving the survey open longer would have increased the sample size.

As a result, another limitation may be the sample size of this study (n = 181). Other receptivity studies had substantially larger participant numbers. This may explain some of the contradictions this study had with other receptivity studies regarding significant predictors of teachers' attitudes and behavior intentions. In addition, one subgroup was very small (ESL education teachers; n = 10), which may have affected results regarding potential differences in receptivity between general educators and ESL educators. In addition, there was approximately a 10% survey response rate, which may have had an effect on external validity. The survey respondents were self-selected; thus, there may be participant bias for or against integrated STEM education (e.g., some participants may have decided to take the survey because they were STEM confident or had strong feelings against STEM education).

Another limitation may be the narrow pool from which the participants were or drawn. This study sought participants from one large school district. This may have limited the participant diversity (e.g., number of ESL teachers). Further, it is likely that the lack of diversity, particularly the low number of ESL teachers, affected the analysis results (i.e., receptivity differences between general and ESL education teachers). In addition, most of the participants taught at suburban schools that surrounded a medium-sized western city. Including participants from rural and urban school districts within the state, for example, might have improved, at the very least, the diversity of teachers' perspectives, insights, and concerns associated with integrated STEM education in the elementary grades.

Finally, another limitation of the study may be related to the design of the survey instrument. Two negatively keyed items were used in the behavior intentions index--

survey items S10 and S13. There is controversy among researchers regarding the use of negatively keyed items on Likert scale survey instruments (Croasman & Ostrom, 2011; Barnette, 2000). Barnette (2000) asserts that negative keyed items are unnecessary when participants can be trusted to make thoughtful and honest responses. In some cases, Barnette (2000) explains that negatively keyed items can affect the internal consistency (increase and decrease), which ultimately affects the validity of the survey instrument. In addition, Weems, Onwuegbuzie, and Collins (2006) posit that there is evidence to support that some participants respond differently to positively and negatively keyed Likert-type items, which can affect Mean or summed scores on the scale indices. They state that participants reading ability can play a factor in this. Thus, ensuring that all items are one-directional (positive) may improve the internal consistency, provide a more accurate index scale Mean or summed score, which may ultimately improve the validity of the survey instrument in future studies.

Aside from the limitations, this study adds to the literature previously done on receptivity. This study yields new knowledge regarding elementary teachers' positive receptivity, perceptions, and concerns associated with integrated STEM education in the elementary grades. Consequently, this knowledge provides a starting point to address factors and begin future discourse to ease implementation of integrated STEM education into the elementary grades.

Future Research

The present study looked at elementary teachers' receptivity to integrated STEM education in the elementary grades. Other studies might look at administrators', parents', or classified (intervention) assistants' receptivity to integrated STEM education in the

elementary grades. Further, it would be interesting to learn more about secondary teachers', administrators', teacher educators', STEM educators', and STEM professionals' receptivity to STEM education in grades K-12.

A study similar to this might be conducted in schools that are transitioning to integrated STEM education. Future research might also modify this study in order to conduct it in schools that have already implemented STEM education school wide to see if receptivity, perspectives, or concerns are different in designated STEM schools.

Additionally, future research might include looking at other demographic subgroups where differences in receptivity may occur (i.e., personal--gender, age, race/ethnicity, and education; school—urban/suburban/rural and large/small). Finally, future research might include looking at different dependent and independent variables. For example, receptivity can be redefined to include more than two dependent variables. Moroz and Waugh (2000) defined receptivity as having four dependent variables: (a) overall feeling, (b) attitudes, (c) behavior intentions, and (d) behavior. Other receptivity studies have included many different independent variables. For example, Waugh and Godfrey (1995) used six independent variables in their study: (a) non-monetary cost benefit, (b) the alleviation of fears and concerns about the change, (c) participation in school decisions about the change, (d) practicality of the change in the classroom, (e) support from senior staff for the change, and (f) comparison of various aspects of the change with the previous system. These are examples that have been done previously, but researchers can also develop their own variables based on unique factors affecting participants and settings.

Forthcoming studies such as these can add to the literature to provide additional knowledge regarding teachers' (and other stakeholders') receptivity to integrated STEM education in grades K-16. Further, this understanding may ease potential implementation of integrated STEM education should it be mandated in the near future.

Final Thoughts

Taking into account that STEM education is presently on the nation's consciousness, this study contributes to knowledge that can assist in moving integrated STEM education forward. The objective is to ensure students will have an opportunity to experience innovative education that can contribute to preparing students to compete for domestic STEM jobs and possibly produce the next innovation that will propel the U.S. forward and help to keep the U.S. globally competitive in the future.

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Appendix A

Receptivity to Integrated STEM Education in the Elementary Grades Survey

Integrated Science, technology, engineering, and mathematics (STEM) education is an interdisciplinary approach to learning where three or more STEM contents are integrated during lessons and units. Students must apply problem solving skills and their knowledge of STEM content to solve real world problems that help them make connections between school, community, and the world (Park, 2011; Tspuros, Kohler, & Hallinen, 2009). For example, a STEM lesson might merge mathematics and science content logically through an engineering lesson, unit, and/or project (Merrill & Daugherty, 2010). Further, STEM activities should be standards based (Merrill, 2009), real world, and employ problem-based teaching strategies (Breiner, 2012).

Mark the location on the scale that best represents how you feel toward STEM education in the elementary grade levels (K-6). The middle position (fourth space) represents a neutral position.

---

1. Undesirable ____ ____ ____ ____ ____ ____ ____Desirable
2. Not Valuable____ ____ ____ ____ ____ ____ ____Valuable
3. Foolish____ ____ ____ ____ ____ ____ ____Wise
4. Absurd____ ____ ____ ____ ____ ____ ____Reasonable
5. Unrealistic____ ____ ____ ____ ____ ____ ____Realistic
6. Unimportant____ ____ ____ ____ ____ ____ ____Important
7. Unnecessary____ ____ ____ ____ ____ ____ ____Necessary
8. Boring____ ____ ____ ____ ____ ____ ____Exciting
9. Unwanted____ ____ ____ ____ ____ ____ ____Wanted

Circle the number that best represents your perspective on the following statements and questions: 1 = disagree very strongly, 2 = disagree strongly, 3 = disagree, 4 = neutral, 5 = agree, 6 = agree strongly, and 7 = agree very strongly

	Behavior Intentions	**Disagree Very Strongly**	**Disagree Strongly**	**Disagree**	**Neutral**	**Agree**	**Agree Strongly**	**Agree Very Strongly**
10.	In my actions toward and communication with other staff, I will probably actively and openly oppose the implementation of appropriately leveled STEM education into K-6 grade levels.	1	2	3	4	5	6	7
11.	In my actions toward and communication with other staff, I will probably actively and openly support the adoption and implementation of appropriately leveled STEM education into K-6 grade levels.	1	2	3	4	5	6	7
12.	In my actions toward and communication with other staff, I will probably praise the adoption and implementation of appropriately leveled STEM education into K-6 grade levels.	1	2	3	4	5	6	7
13.	In my actions toward and communication with other staff, I will probably resist the adoption and implementation of appropriately leveled STEM education into K-6 grade levels.	1	2	3	4	5	6	7
14.	In my actions toward and communication with other staff, I will assume the stance that adopting and implementing appropriately leveled STEM education in K-6 grade levels is achievable and hence should be supported.	1	2	3	4	5	6	7
15.	In my actions toward and communication with other staff, I will assume that the stance that STEM education can be adapted to the needs and abilities of students in K-6 grade levels.	1	2	3	4	5	6	7

	Perceived School and Other Support	**Disagree Very Strongly**	**Disagree Strongly**	**Disagree**	**Neutral**	**Agree**	**Agree Strongly**	**Agree Very Strongly**
16.	There are regular meetings (e.g., grade level and PLCs) at which I can raise any potential concerns about the possible adoption and implementation of STEM education.	1	2	3	4	5	6	7
17.	If problems should arise with implementing STEM education, I can turn to a more experienced teacher.	1	2	3	4	5	6	7
18.	I feel confident that I can get good support from other teachers and administrators whenever I have problems with shortages of materials, resources, and equipment needed for teaching STEM.	1	2	3	4	5	6	7
19.	I feel Wednesday' and other professional trainings are usually informative, and they will beneficial for assisting teachers on how to best implement STEM curriculum.	1	2	3	4	5	6	7
20.	I feel confident that any fears, problems, or apprehension that may come up by implementing STEM education can sometimes be solved through informal conversations at school.	1	2	3	4	5	6	7
21.	The majority of teachers at this school will support the adoption and implementation of STEM education.	1	2	3	4	5	6	7
22.	The administration at this school will support the adoption and implementation of STEM education.	1	2	3	4	5	6	7
23.	The majority of my students' parents will support the adoption and implementation of STEM education.	1	2	3	4	5	6	7

	Perceived Practicality	**Disagree Very Strongly**	**Disagree Strongly**	**Disagree**	**Neutral**	**Agree**	**Agree Strongly**	**Agree Very Strongly**
24.	Does the inquiry, problem-based slant of STEM education suit your classroom teaching style?	1	2	3	4	5	6	7
25.	Does the inquiry, problem-based slant of STEM education reflect your educational philosophy?	1	2	3	4	5	6	7
26.	Will STEM education provide a sufficient variety of classroom learning experiences (e.g., cooperative, individual, student centered, teacher directed learning)?	1	2	3	4	5	6	7
27.	Is STEM education sufficiently flexible to manage in day-to-day use in the classroom?	1	2	3	4	5	6	7
28.	Does STEM education align with the educational needs of K-6 students?	1	2	3	4	5	6	7
29.	Is STEM education appropriate for K-6 students' abilities and learning readiness?	1	2	3	4	5	6	7
	Issues of Concern	**Disagree Very Strongly**	**Disagree Strongly**	**Disagree**	**Neutral**	**Agree**	**Agree Strongly**	**Agree Very Strongly**
30.	I am concerned with the issue of aligning Common Core State Standards (CCSS) to STEM education lessons and units.	1	2	3	4	5	6	7
31.	Sufficient attention to current student achievement in mathematics and literacy are a cause of concern in regard to implementing STEM education.	1	2	3	4	5	6	7
32.	I am concerned that the implementation of STEM education will result in lower student achievement.	1	2	3	4	5	6	7
33.	I am concerned that the implementation of STEM education will leave to little time for other content areas such as literacy and social studies.	1	2	3	4	5	6	7
34.	I am concerned with classroom management issues that may arise due the implementation and the everyday use of STEM curriculum.	1	2	3	4	5	6	7

35.	I am uncertain that I have appropriate and sufficient content knowledge in one or more of the content areas emphasized by STEM curricula	1	2	3	4	5	6	7

Demographic Information

Teaching Experience

List the total number of years, not including this year, you have of certified contractual teaching experience _____

Teaching Assignment

Identify your current teaching assignment by selecting one of the following:

General Education Staff

Primary K-3_____ Intermediate 4-6_____

Special Education and ESL Staff

Sped K-3_____ Sped. 4-6_____ Sped other_____(Write in grade levels you teach)

ESL K-3_____ ESL 4-6_____ ESL other_____(Write in grade levels you teach)

School Demographics

Is the school you currently work for Title 1 eligible: Yes____ No____

What is the STAR performance rating (number of stars) of the school you work for?

STAR rating_____

Thank you for participating in this survey.

Appendix B

Research Question, Survey Item Alignment, Analyses Alignment

Research Question	Survey Items (S)	Data Analysis
1. What is elementary teachers' degree of receptivity to implementing integrated STEM education in the elementary grades?	R1 For items S1-S9, indicate your viewpoint concerning implementation of STEM education into the elementary grade levels. (Note: For the first nine items (S1-S9), participants will provide ratings to indicate their responses to items appearing on a semantic differential scale that includes adjective pairs at opposite ends of an attitudinal spectrum with seven rating points between them. **Attitude:** S1: undesirable/desirable S2: not valuable/valuable S3: foolish/wise S4: unreasonable/reasonable S5: unrealistic/realistic S6: unimportant/important S7: unnecessary/necessary S8: boring/exciting S9: unwanted/wanted **Behavior Intentions:** S10: In my actions and communication with other staff, I will probably actively and openly oppose the implementation of appropriately leveled STEM education into the K-6 grade levels. S11: In my actions toward and communication with other staff, I will probably actively and openly support the adoption and implementation of appropriately leveled STEM education into the K-6 grade levels. S12: In my actions toward and communication with other staff, I will probably praise the adoption and implementation of appropriately leveled STEM education into the K-6 grade levels. S13: In my actions toward and communication with other staff, I will probably resist the adoption and implementation of appropriately leveled STEM education into the K-6 grade levels.	Descriptive

	S14: In my actions toward and communication with other staff, I will assume the stance that adopting and implementing appropriately leveled STEM education in the K-6 grade levels is achievable and hence should be supported. S15: In my actions toward and communication with other staff, I will assume the stance that STEM education can be adapted to the needs and abilities of students in the K-6 grade levels.	
2. What differences, if any, exist among selected elementary teacher subgroups in receptivity to integrated STEM education in the elementary grades?	**Attitude:** S1-S9 (listed above) **Behavior Intentions:** S10-S15 (listed above) Demographic and School Categories: Obtained from the following demographic data: **Teaching experience** (continuous in whole years) **Teaching Assignment** (General, Special, ESL) **Grade-level assignment** (primary, intermediate, Sped., and ESL) **School STAR rating** (1 through 5; 1= lowest rating, 5 = highest rating) **School Title 1 eligibility** (yes or no)	Independent t-test Mann-Whitney U One-way Analysis of Variance
3. What relationships, if any, exist between elementary teachers' receptivity to and potential concerns associated with implementing integrated STEM education in the elementary grades and their perceived school and	**Attitude:** S1-S9 (listed above) **Behavioral Intentions:** S10-S15 (listed above) **Perceived School/Other Support:** S16: There are regular meetings (e.g., grade level and PLCs) at which I can raise any potential concerns about potential adoption and implementation of STEM education. S17: If problems should arise with implementing STEM education, I can turn to a more experienced teacher. S18: I feel confident that I can get good support from other teachers and administrators whenever I may have problems with shortages of materials, resources, and equipment needed for teaching STEM. S19: I feel Wednesday's—and other professional	Pearson product-moment correlations Multiple regression

other types of support, perceived practicality for implementing integrated STEM education in the elementary grades, and teaching experience?	trainings are usually informative, and they will be beneficial for assisting teachers on how to best implement STEM education S20: I feel confident that any fears, problems, or apprehension that may come up by implementing STEM education can sometimes be solved through informal conversations at school. S21: The majority of teachers at this school will support the adoption and implementation of STEM education. S22: The administration at this school will support the adoption and implementation of STEM education. S23: The majority of my students' parents will support the adoption and implementation of STEM education. **Perceived Practicality:** S24: Does the inquiry, problem-based slant of STEM education suit your classroom teaching style? S25: Does the inquiry, problem-based slant of STEM education reflect your educational philosophy? S26: Will STEM education provide a sufficient variety of classroom learning experiences (e.g., cooperative and individual learning, or student centered and teacher directed learning)? S27: Is STEM education sufficiently flexible to manage in day-to-day classroom implementation? S28: Does STEM education align with the educational needs of K-6 students? S29: Is STEM education appropriate for K-6 students' abilities and learning readiness? **Issues of Concern:** S30: I am concerned with the issue of aligning Common Core State Standards (CCSS) to STEM education lessons and units. S31: Sufficient attention to current student achievement in mathematics and literacy are a cause of concern in regard to implementing STEM education.

S32: I am concerned that the implementation of STEM education will result in lower student achievement.

S33: I am concerned that the implementation of STEM education will leave little time for other content areas such as literacy and social studies.

S34: I am concerned with classroom management issues that may arise due the implementation and the everyday use of STEM curriculum.

S35: I am uncertain that I have appropriate and sufficient content knowledge in one or more of the content areas emphasized by STEM curricula.

Appendix C

Survey Questions, Sources, and Item Adaptations

Receptivity: (1) general attitudes, and (2) behavioral and communication intentions

Perceived school and other types of support
Perceived practicality of STEM education in the elementary grades
Issue of concern associated with implementing STEM education

Nine adjective pairs with a "seven-point semantic differential" will be used to quantify general attitudes toward STEM education in elementary grade levels (Lee, 2000, p. 112).

Attitudes Toward STEM Education

Question Source	Question	Adapted Question
1. Researcher		undesirable/desirable
2. Lee (2000)	valuable/invaluable	not valuable/valuable
3. Lee (2000)	wise/foolish	foolish/wise
4. Lee (2000)	intelligent/absurd	unreasonable/reasonable
5. Lee (2000)	realistic/unrealistic	unrealistic/realistic
6. Researcher		unimportant/important
7. Lee (2000)	necessary/unnecessary	unnecessary/necessary
8. Researcher		boring/exciting
9. Researcher		unwanted/wanted

The remaining survey questions will use a 7-point Likert-type scale: (1) disagree very strongly, (2) disagree strongly, (3) disagree, (4) neutral, (5) agree, (6) agree strongly, (7) agree very strongly (Lee, 2000, p. 112).

Behavior Intentions Toward STEM Education

Citation of study	Question	Adapted question
10. Waugh & Godfrey (1995)	In my behavior and communication with others, I will probably actively and openly oppose the Unit Curriculum from 1992 to 1994.	In my actions and communication with other staff, I will probably actively and openly oppose the implementation of appropriately leveled STEM education into the K-6 grade levels.

11. Waugh & Godfrey (1995)	In my behavior and communication with others, I will probably actively and openly support the Unit Curriculum from 1992 to 1994.	In my actions toward and communication with other staff, I will probably actively and openly support the adoption and implementation of appropriately leveled STEM education into the K-6 grade levels.
12. Waugh & Godfrey (1995)	In my behavior and communication with others, I will probably praise the Unit Curriculum from 1993 to 1994.	In my actions toward and communication with other staff, I will probably praise the adoption and implementation of appropriately leveled STEM education into the K-6 grade levels.
13. Waugh & Godfrey (1995)	In my behavior and communication with others, I will probably resist the Unit Curriculum from 1993 to 1994.	In my actions toward and communication with other staff, I will probably resist the adoption and implementation of appropriately leveled STEM education into the K-6 grade levels.
14. Waugh & Godfrey (1995)	In my behavior and communication with other teachers, I will tell them that Unit Curriculum outlines are flexible and hence supportable from 1992 to 1994.	In my actions toward and communication with other staff, I will assume the stance that adopting and implementing appropriately leveled STEM education in the K-6 grade levels is achievable and hence should be supported.
15. Waugh & Godfrey (1995)	In my behavior and communication with other teachers, I will tell them that Unit Curriculum can be adapted to the needs and abilities of students from 1992 to 1994.	In my actions toward and communication with other staff, I will assume the stance that STEM education can be adapted to the needs and abilities of students in the K-6 grade levels.

Teachers will respond to a 7 point Likert scale: (1) disagree very strongly, (2) disagree strongly, (3) disagree, (4) neutral, (5) agree, (6) agree strongly, (7) agree very strongly (Lee, 2000, p. 112).

Perceived School and Other Support		
Citation of study	Question	Adapted question
16. Lee (2000)	There are regular meetings at which I can raise my worries and doubts about the implementation of EE.	There are regular meetings (e.g., grade level and PLCs) at which I can raise any potential concerns about potential adoption and implementation of STEM education.
17. Lee (2000)	Whenever there are problems of implementing EE, there is a senior teacher whom I can ask for advice.	If problems should arise with implementing STEM education, I can turn to a more experienced teacher.
18. Lee (2000)	There is good support whenever I have problems, such as a shortage of books and equipment, related to EE.	I feel confident that I can get good support from other teachers and administrators whenever I may have problems with shortages of materials, resources, and equipment needed for STEM.
19. Lee (2000)	There are regular school-based talks or training programs at which I can learn how to teach EE.	I feel Wednesday's and other professional trainings are generally informative, and they will be beneficial for assisting teachers on how to implement STEM education.
20. Waugh & Godfrey (1995)	Any fears, problems, or apprehension I have about the Unit Curriculum can sometimes be solved informally in general conversations at school.	I feel confident that any fears, problems, or apprehension that may come up by implementing STEM education can sometimes be solved in informal conversations at school.

21. Lee (2000)	The majority of teachers in this school support EE.	The majority of teachers at this school will support the adoption and implementation of STEM education.
22. Waugh & Godfrey (1995)	In your opinion, the principal at this school supports the Unit Curriculum.	The administration at this school will support the adoption and implementation of STEM education.
23. Lee (2000)	In my opinion, the majority of parents in this school supports to implementation of EE in this school.	The majority of my students' parents will support the adoption and implementation of STEM education.

Teachers will respond to a 7 point Likert scale: (1) disagree very strongly, (2) disagree strongly, (3) disagree, (4) neutral, (5) agree, (6) agree strongly, (7) agree very strongly (Lee, 2000, p. 112).

Perceived Practicality

Citation of study	Question	Adapted question
24. Waugh & Godfrey (1993)	Do the course outlines suit your classroom teaching style?	Does the inquiry, problem-based slant of STEM education suit your classroom teaching style?
25. Waugh & Godfrey (1993)	Do the course outlines sufficiently reflect your educational philosophy?	Does the inquiry, problem-based slant of STEM education reflect your educational philosophy?
26. Waugh & Godfrey (1993)	Do the course outlines provide a sufficient variety of classroom learning experiences?	Will STEM education provide a sufficient variety of classroom learning experiences (e.g., cooperative and individual learning, or student centered and teacher directed learning)?
27. Waugh & Godfrey (1993)	Do the course outlines provide sufficient flexibility to help manage the day-to-day running of the classroom?	Is STEM education sufficiently flexible to manage in the day-to-day in the classroom?

28. Waugh & Godfrey (1995)	Is the classroom content tuned to the needs of the students?	Does STEM education align with the educational needs of K-6 students?
29. Researcher		Is STEM education appropriate for K-6 students' abilities and learning readiness?

Teachers will respond to a 7 point Likert scale: (1) disagree very strongly, (2) disagree strongly, (3) disagree, (4) neutral, (5) agree, (6) agree strongly, (7) agree very strongly (Lee, 2000, p. 112).

Issues of Concern Associated with Implementing STEM Education in Elementary Grade Levels

Citation of study	Question	Adapted question
30. Waugh & Godfrey (1995)	The monitoring standards issue is causing me concern in regard to the Unit Curriculum.	I am concerned with the issue of aligning Common Core State Standards (CCSS) to STEM education lessons and units.
31. Waugh & Godfrey (1995)	Numeracy and literacy issues are causing me concern in regard to the Unit Curriculum.	Sufficient attention to current students achievement issues in mathematics and literacy are a cause of concern in regard to implementing STEM education.
32. Lee (2000)	I am concerned the introduction of EE will result in lower academic performance among students at this school.	I am concerned that the implementation of STEM education will result in lower student achievement.
33. Lee (2000)	I am concerned that the introduction of EE will lead to less tine being available for the teaching of the subject syllabus.	I am concerned that the implementation of STEM education will leave little time for other content areas such as literacy and social studies.

34. Lee (2000)	Disciplinary problems are causing me concern in regard to the teaching of EE at this school.	I am concerned with classroom management issues that may arise due the implementation and the everyday use of STEM curriculum.
35. Researcher		I am uncertain that I have appropriate and sufficient content knowledge in one or more content areas emphasized by STEM curricula.

Teachers will respond to a 7 point Likert scale: (1) disagree very strongly, (2) disagree strongly, (3) disagree, (4) neutral, (5) agree, (6) agree strongly, (7) agree very strongly (Lee, 2000, p. 112).

Appendix D

Interview Questions

Statement: Integrated Science, technology, engineering, and mathematics (STEM) education is an interdisciplinary approach to learning where three or more STEM contents are integrated during lessons and units. Students must apply problem solving skills and their knowledge of STEM content to solve real world problems that help them make connections between school, community, and the world (Park, 2011; Tspuros, Kohler, & Hallinen, 2009). For example, a STEM lesson might merge mathematics and science content logically through an engineering lesson, unit, and/or project (Merrill & Daugherty, 2010). Further, STEM activities should be standards based (Merrill, 2009), real world, and employ problem-based teaching strategies (Breiner, 2012).

1. If your school were to implement integrated STEM education, what would your initial reaction be? What are your concerns or worries, if any?
2. From your point of view, what are the potential benefits, if any, to implementing integrated STEM education in the elementary grades?
3. From your point of view, what are some potential obstacles, if any, to implementing integrated STEM education in elementary grades?
4. Generally speaking, do you believe there would be support for implementing integrated STEM education in your school by your colleagues? by your administrators?
5. What other perspectives would you offer concerning the implementation of integrated STEM education that I have not asked?

Appendix E

Participation Flyer

Teachers, how do you feel about integrated STEM education in the elementary grades?

You Can Have a Voice by Participating in an Online Survey!

The survey will take only15-20 minutes of your time—there are "NO" written response questions.
If you are a certified elementary (general, ELL, Sped.) teacher, simply pull a tab at the bottom of this page and go to the URL to have a voice in the matter. If you have any questions concerning this research study, please call me at 775-224-0000 or email: receptivity@yahoo.com

My name is Troy Thomas, and I am a doctoral student in the College of Education at the University of Nevada, Reno. I am seeking your participation in a study that I am conducting.

Participation is voluntary and there are no benefits to you for participating with the exception of voicing your feelings and perceptions, which may contribute to change in the field of education. All survey data will remain anonymous.

The purpose of the study is to investigate elementary teachers' receptivity to integrated STEM education and factors, if any, that relate to receptivity. The results may influence future instructional design for pre-service teachers and professional development design for in-service teachers related to educational reform.

URL: https://www.surveymonkey.com/s/XRCG8MN	**URL: https://www.surveymonkey.com/s/XRCG8MN**	**URL: https://www.surveymonkey.com/s/XRCG8MN**	**URL: https://www.surveymonkey.com/s/XRCG8MN**	**URL: https://www.surveymonkey.com/s/XRCG8MN**	**URL: https://www.surveymonkey.com/s/XRCG8MN**	**URL: https://www.surveymonkey.com/s/XRCG8MN**	**URL: https://www.surveymonkey.com/s/XRCG8MN**	**URL: https://www.surveymonkey.com/s/XRCG8MN**	**URL: https://www.surveymonkey.com/s/XRCG8MN**	**URL: https://www.surveymonkey.com/s/XRCG8MN**	**URL: https://www.surveymonkey.com/s/XRCG8MN**

Note. The flyer was formatted to fit on one page.

Appendix F

Email Script

Dear Principals and Teachers,

Principals: please forward email to staff (see authorization attachments).

My name is Troy Thomas, and I am a doctoral candidate in the College of Education at the University of Nevada, Reno. I am seeking participation in my research titled, "*Elementary Teachers' Receptivity to Integrated STEM Education in the Elementary Grades*." I will be surveying certified elementary teachers in the Washoe County School District to learn about elementary teachers' receptivity to integrated STEM education, as well as factors, if any, that may relate to receptivity. Experience and familiarity with integrated STEM education is not necessary to complete the survey. Completion of the survey is estimated to take no longer than 20 minutes. For only six to eight teachers who volunteer for and are randomly selected for a follow-up interview, an additional 20-30 minutes of time will be necessary.

Your participation in this study is voluntary. If you choose not to participate or to withdraw from the study at any time, there will be no penalty. The results of the research will be published, but your name, name of your school, and school district will not be used. If you have any questions concerning this research study, please call me at 775-224-0000 or email: receptivity@yahoo.com

Please click on the URL to take the survey:
https://www.surveymonkey.com/s/XRCG8MN

Thank you for your participation

Appendix G

Email Script (day seven and fourteen, 2 and 3)

Dear Principals and Teachers,

Principals: please forward email to staff (see authorization attachments).

This is a reminder that the survey will be up for (fourteen/seven) more days.

My name is Troy Thomas, and I am a doctoral student in the College of Education at the University of Nevada, Reno. I am seeking your participation in my research titled, "Elementary Teachers' Receptivity to Integrated STEM Education in the Elementary Grades." I will be surveying certified elementary teachers in the Washoe County School District to learn about elementary teachers' receptivity to integrated STEM education, as well as factors, if any, that may relate to receptivity. Experience and familiarity with integrated STEM education is not necessary to complete the survey. Completion of the survey is estimated to take no longer than 20 minutes. For six to eight teachers who volunteer for and are randomly selected for a follow-up interview, an additional 20-30 minutes of time will be necessary.

Your participation in this study is voluntary. If you choose not to participate or to withdraw from the study at any time, there will be no penalty. The results of the research will be published, but your name and the name of your school will not be used. If you have any questions concerning this research study, please call me at 775-224-0000 or email: receptivity@yahoo.com

Please click on the URL to take the survey:
https://www.surveymonkey.com/s/XRCG8MN

Thank you for your participation

Appendix H

Verbal Script

My name is Troy Thomas. I am a doctoral student here in the College of Education. I am seeking your participation in my research entitled, *Elementary Teachers' Receptivity to Integrated STEM Education in the Elementary Grades*. I am surveying certified elementary teachers working in the Washoe County School District to learn about elementary teachers' receptivity to STEM education, as well as factors, if any, that may relate to teachers' receptivity. Completion of the survey is estimated to take no longer than 20 minutes. An additional 20-30 minutes is estimated for six to eight teachers who volunteer and are randomly selected to participate in a follow-up interview. Participants can volunteer to only complete the online survey without participating in an interview.

Your participation in this study is voluntary. If you choose not to participate or to withdraw from the study at any time, there will be no penalty. The results of the research will be published, but all participants and schools will remain anonymous. If you have any questions concerning this research study, please call me at 775-224-0000 or email: receptivity@yahoo.com

Appendix I

Information Sheet

University of Nevada, Reno Social Behavioral Institutional Review Board
Information Sheet for Teachers to Participate in a Research Study

Title of Study: Elementary Teachers' Receptivity to Integrated STEM education in the Elementary Grades.
Investigators: Lynda R. Wiest, Ph.D., College of Education, MS 299, University of Nevada, Reno, Reno NV 89557; 775-682-7868. Troy Thomas, College of Education, MS 299, University of Nevada, Reno, Reno NV 89557; 775-224-0000.
Protocol #: 2014S033
Sponsor: N/A

Purpose: This study seeks to investigate elementary teachers' receptivity to STEM education and factors, if any, that may relate to receptivity.

Procedures: This study will take approximately 15-20 minutes to complete the online survey and 30 minutes more if you volunteer and are randomly selected to participate in a face-to-face or phone interview.

Discomforts and Risks: This study poses no greater than minimal risk of harm, except in the event that you may have negative perceptions toward something asked in the survey or interview, which may cause some frustration.

Benefits: There are no direct benefits to you for participating in this study.

Statement of Anonymity/confidentiality: This study will not gather any form of identifying information from survey completers and is therefore completely anonymous. Data for those who participate in voluntary interviews will remain confidential.

Right to ask questions and contact information: You may ask questions of the researcher at any time by emailing Troy Thomas at receptivity@yahoo.com. You may call Troy at 775-224-0000. Office of Human Research Protection provides oversight for this study; you may call them if you have any concerns about the conduct of the study at 775-327-2367.

Voluntary participation: Your participation in this study is voluntary. You may discontinue at any time without penalty or permission.

Thank you for your participation in this study.

___ Yes, I wish to continue to the survey questions.

___ No, I do not want to participate.