ABSTRACT

THE EFFECTS OF STEM-RICH CLINICAL PROFESSIONAL DEVELOPMENT ON ELEMENTARY TEACHERS' SENSE OF SELF-EFFICACY IN TEACHING SCIENCE

By

Michael David Trimmell

May 2015

There is a deficiency of science, technology, engineering, and mathematics (STEM) qualified college graduates to meet current workforce demands. Further, there is a weak pipeline of STEM qualified educators, which are needed to help produce the skilled candidates necessitated by these demands. One program aimed at creating highly qualified STEM teachers was the Raising the Bar for STEM Education in California: Preparing Elementary Teachers in a Model, Scalable, STEM-Rich Clinical Setting (Raising the Bar Program). The Raising the Bar professional development program focused on addressing deficiencies in elementary teachers' pedagogical content knowledge, specifically in science. The purpose of this study was to determine the effects of the Raising the Bar professional development program on elementary master teachers' sense of self-efficacy in teaching science. Research shows there is a clear link between self-efficacy and outcome expectancy to improve student outcomes in STEM fields.

This study utilized an explanatory mixed methods approach. Specifically, a quasi-experimental design was followed to collect, first, quantitative data, and then, qualitative data. The quantitative data consisted of survey data collected from each of two groups: the treatment group of master teachers participating in the Raising the Bar professional development series, and the control group of master teachers not participating in the professional development. The qualitative data was collected in the form of two focus group interviews, one from each group. Further, two university student teacher coordinators were interviewed to add depth and perspective throughout the entire professional development process.

Quantitative and qualitative data were analyzed to determine the effects of the Raising the Bar professional development on teachers' sense of self-efficacy in teaching science. The major research findings indicated that the STEM-rich professional development was successful in significantly increasing teachers' sense of self-efficacy in teaching science. Further, the findings of the study demonstrated that there is a clear need for focus on science across the curriculum, a clear need for a science-specific professional development model, and a clear need for inclusion of specific content courses as a requirement in administrative credential programs. As a result of the research, a science-specific model of professional development was created. The proposed model suggests that the science-specific professional development must be aligned, intentional, differentiated, ongoing, and purposeful.

Recommendations based on the findings of this study include further exploration of the factors that positively affect self-efficacy in teaching science. Additionally, it is unclear if self-efficacy alone is sufficient to improve overall science teaching practice at the elementary level. Research specifically aimed at the factors affecting teachers' sense of self-efficacy in teaching science can help determine the best course of action for teacher credentialing programs, professional development programs, and instructional leaders working in the field.

THE EFFECTS OF STEM-RICH CLINICAL PROFESSIONAL DEVELOPMENT ON ELEMENTARY TEACHERS' SENSE OF SELF-EFFICACY IN TEACHING SCIENCE

A DISSERTATION

Presented to the Department of Educational Leadership

California State University, Long Beach

In Partial Fulfillment

of the Requirements for the Degree

Doctor of Education

in Educational Leadership

Committee Members:

Linda Symcox, Ph.D. (Chair)
Simon Kim, Ph.D.
Phillip Perez, Ed.D.

College Designee:

Marquita Grenot-Scheyer, Ph.D.

By Michael David Trimmell

M.Ed., 2008, National University, Los Angeles, California

May 2015

ACKNOWLEDGEMENTS

Completing my doctorate has been a life-long goal. Much of the process of conducting research and writing a dissertation is solitary. However, throughout the process, there were those that supported me and made this achievement possible. I would like to express my deepest gratitude to my dissertation chair, Dr. Linda Symcox. Dr. Symcox was a constant source of encouragement during the entire program. I am grateful for her time and dedication on my behalf.

I would also like to thank my dissertation committee, Dr. Simon Kim, and Dr. Phillip Pérez. I feel honored that they were willing to serve on my dissertation committee. They both brought such insight, depth, and richness to my study through their revisions and their constant support. Thank you Dr. Kim for steering me in the right direction on the quantitative portion of my study. Thank you Dr. Pérez for being a wonderful boss, mentor, and friend.

I would be remiss if I did not thank the S.D. Bechtel, Jr. Foundation for the opportunity to research the grant-funded program on which my study is based. The work accomplished as a result of the funding provided by the S.D. Bechtel, Jr. Foundation will continue to advance teaching and learning for years to come.

I would like to thank a special group of friends, Stacey Benuzzi, Stephen Glass, and Keeley Lewis, who became invaluable supporters and life-long friends during this amazing journey. I would also like to thank the best cohort ever, cohort six. Cohort six

brought together a cadre of competent, eager, dedicated, and passionate educators. I know that our impact on education will be profound!

I want to thank my mother and my father, Elaine and David Trimmell, for their unwavering support. They have been my greatest examples. They have also been my biggest supporters. It is through their love, encouragement, support, and guidance that gave me the drive to attain such a lofty goal. I also want to thank my in-laws, Jerry and Ellen Ibey for their love and support.

Most importantly, I dedicate this work to my beautiful wife, Shawna Trimmell, and to my wonderful children, Makayla, Landon, Dallin, and Aubrey. Throughout the entire process, Shawna listened patiently as I talked about self-efficacy and cognitive learning theory while pretending to be interested. She encouraged me when I was overwhelmed, and supported me when no one else was around. I want to thank her and my family for the sacrifices they made on my behalf so that I could achieve this goal.

TABLE OF CONTENTS

CHAPTER Page

CHAPTER Page

APPENDIX Page

LIST OF TABLES

TABLE Page

LIST OF FIGURES

FIGURE Page

CHAPTER 1

INTRODUCTION

In 2011, The Center for the Future of Teaching and Learning (CFTL) at WestEd conducted a research study concerning the current state of elementary science education in America. The study concluded that, although educators and the public agree that science education is important, it is not a priority in elementary schools, due to current education accountability requirements that focus on English language arts and mathematics (Dorph, Shields, Tiffany-Morales, Hartry, & McCaffrey, 2011). Furthermore, the report states that about 45% of fifth grade students scored below proficiency on standardized science tests. CFTL reports that across Grades K-5, 40% of teachers reported teaching science less than 60 minutes per week (Dorph et al., 2011, p. 14). These numbers are cause for concern for the future of America if we are to remain leaders in science, technology, engineering, and mathematics (STEM) fields.

One of the major influences on elementary school teachers' comfort level with and ability to teach science is self-efficacy (Akerson & McDuffie, 2002). Self-efficacy is defined as, "peoples' judgment on their capabilities to organize and execute courses of action required to attain designated types of performances" (Bandura, 1986, p. 391). Bandura (1977) hypothesized that the relationship between the level of self-efficacy and the outcome expectancy of a given task would lead to predictable outcomes (p. 207). Many elementary teachers teaching science exhibit low self-efficacy in their ability to teach science (Ginns & Watters, 1999). In fact, many elementary school teachers avoid teaching science due to low self-efficacy (Lee & Housel, 2003). This is especially true given the nature of the credential needed to teach in an elementary school setting. According to the California Commission on Teacher Credentialing (CCTC; 2009), basic science teaching strategies are taught, but little specific science content knowledge is required. Therefore, because many graduates of teaching credential programs do not have a background in science, they have concerns with their confidence and ability to teach science even at the most basic of levels (Ginns & Watters, 1999).

There are many factors believed to be the cause of such low teacher self-efficacy and limited time spent teaching science at the elementary level. Of these factors, teacher preparation programs, lack of professional development for in-service teachers, lack of instructional leadership in science curriculum, and lack of collaboration are prominent.

Problem Statement

For elementary school teachers, teaching science can be an uncomfortable prospect (Akerson & McDuffie, 2002). Moreover, the fact that many graduates of teaching credential programs do not have a background in science leads to concerns with self-efficacy and ability to teach science even at the most basic of levels (Ginns & Watters, 1999). Aside from the lack of pre-service training, teachers' lack of self-efficacy in teaching science is due in part to lack of professional development in science. It has been shown that teachers participating in long-term research based professional development programs display increased self-efficacy in teaching science (Lumpe, Czerniak, Haney, & Beltyukova, 2012). While the positive effects of professional development are noted, the lack of professional development in the area of science is also found in the literature (Buczynski & Hansen, 2010). Even though the lack of pre-service training and lack of effective professional development are prominent in the literature concerning elementary teachers' low self-efficacy in teaching science, they are not the only factors. Leadership is another important factor affecting science-teaching self-efficacy at the elementary level.

The instructional leader, or principal, is another factor affecting the self-efficacy in teaching science of elementary school teachers. Many principals choose to focus their efforts in the areas of language arts and mathematics due to the overarching emphasis placed on these subjects by the California State Standards and the Common Core State Standards (CCSS; California Board of Education, 2012). According to the National Science Teachers Association (NSTA; 2007), effective principal leadership is paramount to successful science teaching at the elementary level. Wahlstrom, Louis, Leithwood, and Anderson (2010) state, "leadership is second only to classroom instruction among school-related factors that affect student learning in school" (p. 3). Previous research suggests that poor instructional leadership is a major cause of low self-efficacy (Edmonds, 1979).

Regardless of the reasons why teachers feel uncomfortable teaching science, the real problem is the effect that low self-efficacy in teaching science has on student learning. Students in the United States continue to rank poorly in science when compared to international students (National Assessment of Educational Progress [NAEP], 2011). In fact, NAEP reports that 68% of eighth grade students performed at the basic level in 2011. The statistics in the state of California paint an even more alarming picture. California scored significantly lower than the national average both in

2009 and in 2011 (NAEP, 2011). The National Science Board (NSB; 2010) reported that, internationally, the United States continues to lag far behind other countries in developing scientific knowledge and literacy.

The fact that children in the United States are falling behind in science is cause for concern. One recent international assessment, the Trends in International Mathematics and Science Study (TIMSS; 2007), found that while scores in mathematics have gone up, science scores have not. On another international test, the Program for International Student Assessment (PISA; 2012), U.S. students performed below average in both math and science. Though the data does not bode well for the United States, there are many efforts to combat the alarming trend. Efforts to increase student engagement, increase accessibility to resources, and better prepare teachers are promising endeavors.

In an effort to improve student learning and outcomes in science, institutions of higher learning have created comprehensive programs to better prepare new teachers. This is extremely important to the future of science education; however, it does not remedy the deficiencies currently in the classroom. The task of improving science education falls to districts and schools through professional development programs. Often, the task falls on the shoulders of ill prepared administrators, lacking self-efficacy in teaching science themselves. There are, however, avant-garde programs that aim to improve science teaching for both the in-service and pre-service teacher. One such collaborative program exists between California State University, Long Beach (CSULB) and Long Beach Unified School District (LBUSD). The program is a grant-funded effort entitled Raising the Bar for STEM Education in California: Preparing Elementary Teachers in a Model, Scalable, STEM-Rich Clinical Setting.

Raising the Bar

The Raising the Bar for STEM Education in California: Preparing Elementary Teachers in a Model, Scalable, STEM-Rich Clinical Setting project is a collaborative project between CSULB and LBUSD. Specifically, the collaboration was between the College of Education (CED) at CSULB, the College of Natural Sciences and Mathematics at CSULB and five schools in LBUSD. The purpose of this unique professional development series was to train both in-service and pre-service teachers in a co-teaching model with an emphasis on STEM content and pedagogy. The focus of the professional development series was to "train teachers to teach the STEM disciplines in an integrated, inquiry-focused way so students understand science and mathematics in a real-world context" (Symcox & Benken, 2012, p. 3).

The Raising the Bar professional development consisted of an initial week-long summer institute followed by a year-long series of 3-hour professional development sessions. There were two major components of the professional development series:

1. Create a pipeline of highly qualified STEM educators by:

a. Intensively training and inspiring 150 highly effective elementary STEM teachers in a residency setting in selected elementary and middle schools (K-6).

b. Creating a co-teaching model involving current and future teachers together in teaching STEM subjects.

c. Integrating STEM content across the teacher-preparation curriculum.

d. Providing opportunities for elementary teachers to attend state STEM conferences.

e. Involving CSULB doctoral students in studying, evaluating, and disseminating the model.

f. Creating a web-based handbook to serve as a resource for establishing similar school/university STEM education programs across California (Symcox & Benken, 2012).

2. Provide a pathway for credentialed teachers to further their education with a focus on STEM content by:

a. Focusing on strengthening current elementary teachers' mathematics and science content and pedagogies.

b. Providing an expedited pathway to gaining and adding a science or math credential.

c. Providing teachers with opportunities to plan and implement STEM activities with their current students (K-8) and during after school events.

d. Creating a cadre of 150 highly qualified STEM educators with the ability to inspire thousands of PreK-Grade 8 students in LBUSD (Symcox & Benken, 2012).

The STEM-rich professional development focused primarily on providing master teachers and student teachers' pedagogical content knowledge around science. The objective was to create a pipeline of "highly qualified pre-service and inservice teachers to teach STEM content effectively in elementary schools" (Symcox & Benken, 2012, p. 4). To accomplish this, the STEM-rich professional development included a pre/post assessment on teachers' knowledge of and sense of self-efficacy in teaching STEM content. Participants were also invited to attend a week-long intensive summer institute. The summer institute featured workshops aimed at delivering STEM content and providing participants with practice using STEM equipment associated with that content. The focus of the summer institute was connecting engineering across the curriculum. Engineering is Elementary (EiE), a curriculum developed by the Boston Museum of Science, was utilized during the 4-day intensive professional development session. Table 1 illustrates the daily activities covered during the summer institute.

TABLE 1. 2012 Summer Institute Daily Program

Day 1	Day 2	Day 3	Day 4
Pre-Survey (STEBI Mathematics & Science Content Knowledge & Efficacy)	What is Engineering?	Engineering is Elementary: Engineering Design Process	Engineering is Elementary: Tower Building
CA Common Core Standards (CACCS), Next Generation Science Standards (NGSS), & 21st Century Skills	Engineering is Elementary: Designing Submersibles	Designing Submersibles	Designing Submersibles & Consumer Product Testing
Engineering is Elementary: What is Technology? Tech in a Bag			Post-Survey

Note. Adapted from "*Raising the Bar for STEM Education in California: Elementary Teachers in a Model, Scalable, STEM-Rich Clinical Setting* Year One Report," by L. Symcox & B. Benken, 2012, p. 4. Copyright 2012 by California State University, Long Beach.

Next, 6 professional development days provided ongoing professional development throughout the school year. The professional development series included topics such as "what is science," unpacking the Next Generation Science Standards

(NGSS), understanding the science of consumer product testing, science unit planning, engineering, and an in-depth conceptual framework for understanding earth, physical, and life sciences (Table 2).

TABLE 2. Continuing Professional Development Topics Throughout the 2012-2013 School Year

October 2, 2012	November 6, 2012	December 4, 2012	February 5, 2013	March 7, 2013	May 7, 2013
What is Science	Next Generation Science Standards	Consumer Product Testing	Unit Planning for Science	Engineering, Earth Science, and Physical Science	Physical Science and Life Science
Pre-Survey					Post-Survey

Note. Adapted from "*Raising the Bar for STEM Education in California: Elementary Teachers in a Model, Scalable, STEM-Rich Clinical Setting* Year One Report," by L. Symcox & B. Benken, 2012, p. 6. Copyright 2012 by California State University, Long Beach.

The overarching focus of these professional development topics was integrating the content participants had learned into inquiry-based lessons across the curriculum. Further, the focus of unit planning for science included co-teaching STEM-based lessons throughout the year. Master teachers and student teachers planned and delivered STEM content in a co-teaching model throughout the school year.

Another aspect of the STEM-rich professional development was to showcase new learning through a "Family STEM Night." In collaboration with the student teacher coordinators, participants were charged with organizing STEM nights at each of their school sites. This aspect of the professional development afforded the participants the opportunity to engage the community in topics around science. It also encouraged all of the participants to design activities, prepare handouts, and display instructional charts (Symcox & Benken, 2012, p. 7). The collaboration between master teachers and student teachers showcased the clinical focus of the STEM-rich professional development.

Literature suggests that elementary teachers' lack self-efficacy in teaching science may be due to poor pre-service training, lack of professional development, and poor instructional leadership. While multiple reasons are discussed, the focus of this dissertation will be on the effects of the STEM-rich professional development on a teacher's sense of self-efficacy in teaching science. The focus will be on the effects of the professional development on self-efficacy, because self-efficacy is linked to how and if teachers will teach a given subject. Self-efficacy can be a determining factor in how often and how well science is taught, which directly effects students' learning and outcomes.

Purpose and Guiding Questions

The purpose of this study was to analyze the effects of professional development on teachers' sense of self-efficacy in teaching science. Self-efficacy is the belief in one's capability to organize and execute the courses of action required to produce given outcomes (Bandura, 1977). Bandura's (1977) work on self-efficacy expounded upon the relationship between self-efficacy and outcome expectancies. Riggs and Enochs (2006) give an example of the type of predictable outcome a correlation between self-efficacy and the outcome expectancy of a given task could lead to:

> An elementary teacher judges her ability to be lacking in science teaching (belief) and consequently develops a dislike for science teaching (attitude). The result is a teacher who avoids teaching science if at all possible (behavior). This strong interrelationship of beliefs, attitudes, and behavior dictates the inclusion of belief measurement in elementary science teaching research. (pp. 625–626)

Thus, this study is important because high self-efficacy is linked to positive behavioral outcomes (Riggs & Enochs, 2006), and teachers with higher self-efficacy can lead to a positive impact on student learning (Arambula-Greenfield & Feldman, 1997). Keys and Bryan (2001) state, “Teacher beliefs about the nature of science, student learning, and the role of the science teacher substantially affect planning, teaching, and assessment” (p. 636). Based on recent national surveys on content knowledge, the lack of self-efficacy may be partially responsible as elementary school teachers’ science content knowledge appears to be lower than it should be in order to provide adequate instruction (Rice, 2005).

This study was guided by the following key questions:

1. Is there a difference in self-efficacy between the teachers that participated in the STEM professional development and teachers that did not participate in the STEM professional development?

2. To what extent do other factors influence elementary teacher's sense of self-efficacy in teaching science? Specifically, which, if any, of the following factors influence self-efficacy?

a. Teacher pre-service knowledge around science.

b. Professional development.

c. Interpersonal supports.

d. Principal instructional leadership.

3. What aspects of the STEM-rich professional development most contributed to teachers’ sense of self-efficacy in teaching science?

Theoretical Framework

The guiding theory for this study is "Self-Efficacy," which is part of a larger theory, "Social Cognitive Theory" (Bandura, 2001). Bandura's (1977) theory states that, "people's level of motivation, affective states, and actions are based more on what they believe than on what is objectively true" (p. 2). This would suggest that the beliefs that people hold about their capabilities are one of the best predictors of human behavior. Human beliefs and behaviors are derived from self-reflection of perceived success and failures. According to Bandura (1986), "the capability that is most distinctly human is that of self-reflection, and it thus a prominent tenant of Social Cognitive Theory" (p. 394). In fact, self-reflection influences the choices people make and the courses of action they pursue (p. 393). To this end, social cognitive theory can be a model for the actions that people take, the effort that they put into a task, and can be a predictor of motivating factors. Individuals tend to select tasks and activities in which they feel competent and confident and avoid those in which they do not. Bandura (1989) asserts, "One is just as much an agent reflecting on one's experiences as in executing the original courses of action" (p. 60).

Widely used, Bandura's (1977) theory of self-efficacy is still relevant today. According to this theory, highly self-efficacious people are more likely to view difficult tasks as something to be mastered rather than something to be avoided (Bandura, 1977, p. 194). There are four domains related to self-efficacy: Performance outcomes; physiological feedback, verbal persuasion; and vicarious experiences (Figure 1).

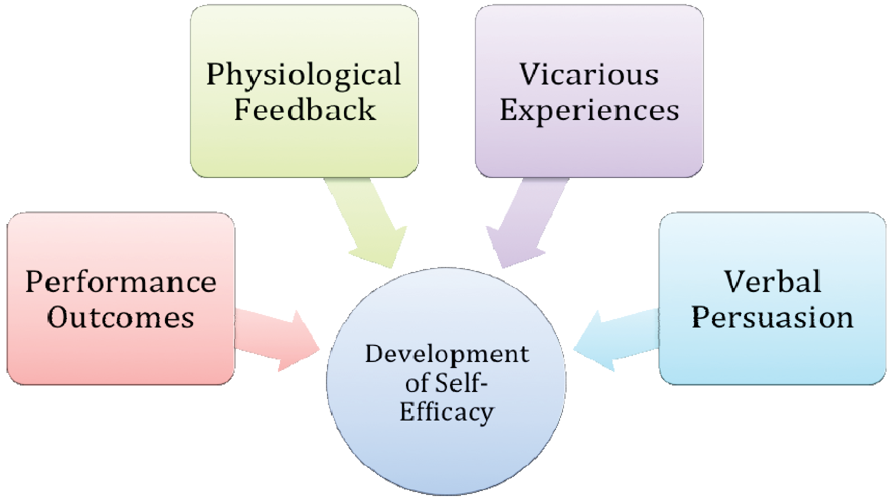

FIGURE 1. Sources of self-efficacy. Adapted from Bandura, 1997, p. 455.

The first source of self-efficacy is performance outcomes. Performance outcomes, or past experiences, are the most important source of self-efficacy (Bandura, 1977, p. 455). Positive past experiences influence self-efficacy on associated tasks (Bandura, 1977, p. 455). Therefore, if a person performs well in a professional development setting, they are more likely to feel confident using that which they learned during the professional development. To the contrary, “individuals with low self-efficacy tend to believe that things are tougher than they really are” (Bandura, 1986, p. 394). The second source of self-efficacy is physiological feedback. Physiological feedback refers to emotional arousal, or how a person reacts physically to a situation. The third tenant of self-efficacy is verbal persuasion. According to Redmond (2010), verbal persuasion can influence self-efficacy through encouragement or discouragement. Finally, vicarious experiences affect self-efficacy. By watching another similar person be successful, one’s own self-efficacy increases (Bandura, 1977, p. 459).

This theory is applicable to this researcher's study because elementary teachers' sense of self-efficacy in teaching science can be a determining factor of how often science it taught, if at all, and how well science is taught. In fact, "research shows that people who regard themselves as highly efficacious act, think, and feel differently from those who perceive themselves as inefficacious. They produce their own future, rather than simply foretell it" (Bandura, 1986, p. 395). The framework also fits because the researcher postulated that if one's self-efficacy in teaching science increased, then beliefs about one's ability would also increase. An increase in beliefs leads to actions and behaviors associated with the positive belief about ability. Those positive actions will lead to perceived success, even in the face of adversity, thus increasing one's sense of self-efficacy (Figure 2). In conclusion, social cognitive theory, and more specifically, self-efficacy are helpful in understanding individual and group behaviors, and the latter is one of the most important factors affecting behavior change.

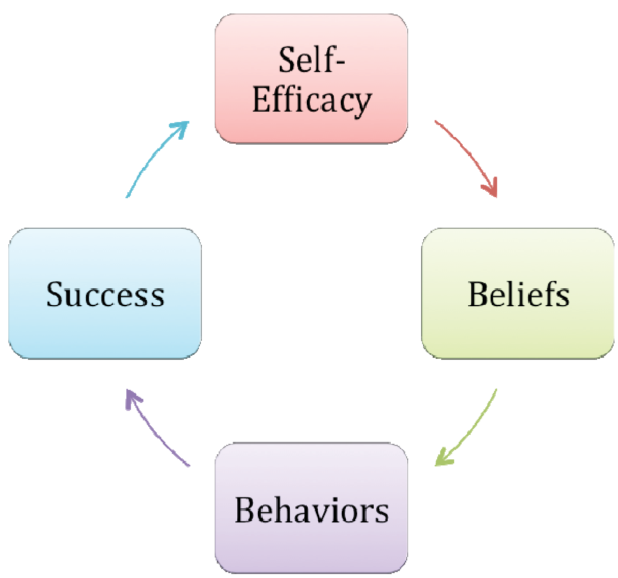

FIGURE 2. Self-efficacy cycle. Adapted from Bandura, 1997, p. 395.

Operational Definitions

Self-efficacy: Peoples' judgment on their capabilities to organize and execute courses of action required to attain designated types of performances (Bandura, 1986, p. 391).

STEBI: Science Teaching Efficacy Belief Instrument.

STEM-rich professional development: Professional development consisting of four major components:

1. Intensively training and inspiring highly effective elementary STEM teachers in a residency setting in selected elementary schools.

2. Creating a co-teaching model involving current and future teachers together in teaching STEM subjects.

3. Integrating STEM content across the teacher-preparation curriculum.

4. Providing opportunities for elementary teachers to attend state STEM conferences.

UTEACH: The UTEACH (Urban Teaching Academy) pathway is a unique opportunity for students to combine pedagogy and practice in a personalized credential program designed to fully prepare future teachers in a hands-on supportive school setting (CED, 2014).

Assumptions and Delimitations

Bias during focus group interviews: Being in a group during an interview may illicit a different response to questions than if each participant was interviewed individually.

Non-response: Non-responses will make comparing the treatment and control groups as well as analyzing the data difficult.

Personal bias: I have a bachelor's degree in cell biology; therefore, my content knowledge may bias my analysis. I am also a school administrator, which biases my views of the role of instructional leadership in the classroom.

Sample size: The study is not generalizable due to the small sample size.

Nature of self-reported scores: Participants may have inflated their self-reported scores on the self-efficacy post-test because there was a perceived increase in knowledge from participation in the STEM professional development.

Self-selection: The participants in both focus group interviews (control group and treatment group) were self-selected. Those that self-selected into the focus group may have done so because they initially had high self-efficacy in teaching science.

Significance

This research is significant because one of the major influences on elementary school teachers' comfort level with and ability to teach science is self-efficacy (Akerson & McDuffie, 2002). Self-efficacy is defined as, "peoples' judgment on their capabilities to organize and execute courses of action required to attain designated types of performances" (Bandura, 1986, p. 391). Bandura (1977) hypothesized that the relationship between the level of self-efficacy and the outcome expectancy of a given task would lead to predictable outcomes (p. 207). Many elementary teachers teaching science exhibit low self-efficacy in their ability to teach science (Ginns & Watters, 1999). In fact, many elementary school teachers avoid teaching science due to low self-confidence, in other words, due to low self-efficacy (Lee & Housel, 2003). According to

CCTC (2009), little science content is required during most teaching credential programs. Therefore, because many graduates of teaching credential programs do not have a background in science, they have concerns with their confidence and ability to teach science even at the most basic of levels (Ginns & Watters, 1999). In a report by the Department of Defense (DoD; 2009), a call for STEM-qualified teachers went out to our nation. The DoD (2009) report states:

> Those teachers who are not proficient in STEM and have not maintained the necessary knowledge and skills have shown to be less effective. As a result, students are less likely to close achievement gaps in STEM and are less prepared for success in the STEM workforce. (p. 2).

Years of poor science teaching have affected the number of STEM-qualified candidates available for jobs in the United States. In fact, an inadequate pipeline of STEM-qualified candidates has led to a STEM crisis on the gross domestic product (GDP) and in the area of defense (DoD, 2009). This research is important because it may help create a pipeline of STEM-prepared educators that can prepare students to enter the STEM workforce. This will help to combat the concern that our global competitors' increased investment in STEM will continue to outpace our own (DoD, 2009). It will also serve to remedy the deficiency in "home grown" STEM-qualified candidates to take the thousands of jobs projected by the U.S. government over the next 10 years (DoD, 2009). Thus, the primary importance of this study is to shed some light on ways to remedy the deficiencies elementary school teachers experience teaching science by providing feedback on the effectiveness of the STEM professional development program. If successful, the STEM-rich clinical model for professional development will also act as a scalable model for STEM-rich professional development that can be used nationally.

Conclusion

There is a deficiency of adequately trained teachers to prepare students to be successful in STEM fields (DoD, 2009). In fact, teachers that are not proficient in STEM are less effective and, as a result, students are less likely to be prepared for success in the STEM workforce (National Science Foundation [NSF], 2006). Low self-efficacy in teaching science is a major factor that affects a teacher's ability to effectively teach STEM. Self-efficacy is defined as "peoples' judgment on their capabilities to organize and execute courses of action required to attain designated types of performances" (Bandura, 1986, p. 391). Self-efficacy is comprised of four major domains: Performance outcomes; physiological feedback, verbal persuasion; and vicarious experiences. Performance outcomes are the most important source of self-efficacy (Bandura, 1977, p. 455). This domain is directly linked to past experiences, which can be either positive or negative. Physiological feedback is the second domain and it refers to how a person reacts physically to a situation (Redmond, 2010). The third domain is verbal persuasion. Verbal persuasion can influence self-efficacy through either encouragement or discouragement (Redmond, 2010). Finally, vicarious experiences can affect self-efficacy. Watching another person be successful at a task can positively affect self-efficacy. To the contrary, watching another person experience failure can negatively affect self-efficacy (Bandura, 1977).

In an effort to increase teachers' sense of self-efficacy in teaching science, and therefore to improve the learning experience of students, CSULB and LBUSD joined to create a STEM-rich professional development series. The professional development, titled, Raising the Bar for STEM Education in California: Preparing Elementary

Teachers in a Model, Scalable, STEM-Rich Clinical Setting, aimed to better prepare teachers to teach in STEM fields. The effort consisted of two components: Creating a pipeline of highly qualified STEM educators and providing a pathway for credentialed teachers to further their education with a focus on STEM content. The focus of this dissertation was to determine if the STEM-rich professional development indeed increased the self-efficacy of teachers in teaching science. An increase in self-efficacy in teaching science could improve the amount and the quality of science education for students, and therefore, better prepare them to enter and be successful in STEM fields.

CHAPTER 2

LITERATURE REVIEW

Introduction

With the passage of No Child Left Behind (NCLB) in 2001, state standards and standardized testing became the norm in K-12 education. This caused a major problem; due to the focus of standardized testing on English language arts and mathematics, science education was ignored in many elementary schools. Much of the authentic problem-solving and critical thinking was replaced by teaching to the test (Au, 2011; Luft, Brown, & Sutherin, 2007). Poor performance on math and language arts assessments led to "response to intervention" (RTI). This increased the number of minutes spent studying language arts and math, but decreased time spent studying science and history. RTI is the process of assessing, analyzing, and re-teaching. Teachers give frequent formative assessments in math and language arts and then analyze the data. From the data analysis, students are grouped into "proficient" and "below proficient" groups. Students falling in the "below proficient" group are placed in a math or language arts class to review the standards on which they struggled in the former common assessment. This cycle of assessing, analyzing, and re-teaching left little room for science instruction as the focus was clearly on proficiency in math and language arts. With the focus on proficiency in math and language arts, science and history instruction were glossed over, or even skipped all together, to provide timely interventions in math and language arts (Spillane, Halverson, & Diamond, 2004).

In their research regarding the loss of science instruction in elementary schools, Marx and Harris (2006) state, "The initial effects of NCLB on science education have been keenly felt in elementary classrooms, where the current policy agenda has left little room for science instruction" (p. 475). Further research conducted by Spillane et al. (2004) found that teachers, "emphasized language arts and mathematics over science in response to testing and accountability policies" (p. 1162). Their work is based on a 4-year longitudinal study of elementary school leadership from the Distributed Leadership Project. This lack of focus on science has caused many science and technology industry leaders to worry about the future (Hoachlander & Yanofsky, 2011).

In addition to the shift in focus, many elementary school teachers lack confidence in teaching science due to low content knowledge and low self-efficacy. Self-efficacy has been positively linked with effective science teaching (Ginns & Watters, 1999). As stated in the theoretical framework of this dissertation, Bandura's (1977) theory of self-efficacy proposes that, "people's level of motivation, affective states, and actions are based more on what they believe than on what is objectively true" (p. 2). According to this theory, highly self-efficacious people are more likely to have a positive outlook on difficult tasks (Bandura, 1977). Focusing on teachers' sense of self-efficacy is one way to help teachers improve their practice of teaching difficult subject matters. Buczynski and Hansen (2010) state, "most U.S. elementary school teachers are not sufficiently prepared to teach science subject matter nor do they have scientific skills to feel confident about teaching science regularly (p. 599). Much of the literature on improving self-efficacy centers on professional development as a way to improve subject matter knowledge and teaching practices (Posnanski, 2002). Other factors shown to positively influence self-efficacy include teacher education (Cakiroglu, Capa-Aydin, & Hoy 2012; Mulholland & Wallace, 2001; Settlage, Southerland, Smith, & Ceglie, 2009), interpersonal support (Friedman, 2003; Tschannen-Moran, & Hoy, 2007), and leadership (Hallinger & Heck, 2002; O'Donnell, & White, 2005). Thus, my literature review will focus on self-efficacy as it relates to teaching science, and more specifically, the various factors positively influencing self-efficacy in teaching science at the elementary level.

Self-Efficacy

Simply stated, self-efficacy is "peoples' judgment on their capabilities to organize and execute courses of action required to attain designated types of performances" (Bandura, 1986, p. 391). Bandura (1977) describes self-efficacy in terms of two factors: action-outcome expectancy through experiences and the development of personal beliefs about ability to perform. He states:

> An outcome expectancy is defined as a person's estimate that a given behavior will lead to certain outcomes. An efficacy expectation is the conviction that one can successfully execute the behavior required to produce the outcomes. Outcome and efficacy expectations are differentiated, because individuals can believe that a particular course of action will produce certain outcomes, but if they entertain serious doubts about whether they can perform the necessary activities such information does not influence their behavior. (p. 193)

Bandura (1997) introduced four domains related to self-efficacy: performance outcomes, physiological feedback, verbal persuasion, and vicarious experiences (Figure 1). Each of these domains will be explored in depth.

Performance Outcomes

Performance outcomes, or past experiences, influence an individual's ability to perform on a future task. If one has performed well at a task previously, one is more likely to feel competent and perform well at a related task (Redmond, 2010). Performance outcomes may be the most influential source of self-efficacy because they provide the most accurate evidence of success or failure for a given task (Bandura, 1997). However, this increase in self-efficacy may be diminished if success attained with broad external assistance, or if the task is perceived easy or meaningless (Ross, 1994). In his seminal study on acquisition of cognitive skills, Schunk (1985) reported that expectations prior to performing a given task affect interpretation of performance outcomes and that subsequent feedback affects self-efficacy and outcome expectancy. It stands to reason that success leads to increased self-efficacy while failures can be detrimental to it. Bandura (1977) states, "after strong efficacy expectations are developed through repeated success, the negative impact of occasional failures is likely to be reduced" (p. 195). In fact, sustained effort can become another source of increased self-efficacy even after the occasional failure, thus increasing overall self-efficacy because one "expects" to succeed even in the face of adversity. For teachers, the most influential period to attain or diminish self-efficacy is usually during the pre-service period, thus informing the importance of multiple positive outcomes as a nascent educator (Ross, 1994; Hoy & Spero, 2005).

Bandura (1986) explained how performance outcomes can act to increase self-efficacy as well as decrease it. In his book *Social foundations of Thought and Action: A Social Cognitive Theory* he stated:

> If people experience only easy successes they come to expect quick results and are easily discouraged by failure. A resilient sense of efficacy requires experience in overcoming obstacles through perseverant effort. Some setbacks and difficulties in human pursuits serve a useful purpose in teaching that success usually requires sustained effort. After people become convinced they have what it takes to succeed, they persevere in the face of adversity and quickly rebound from setbacks. By sticking it out through tough times, they emerge stronger from adversity. (p. 3)

Physiological Feedback

Physiological feedback refers to the influence of emotional arousals on beliefs of efficacy. Emotional arousal, or stress level, is more accurately defined as debilitating fears surrounding a given task (Bandura, 1977). When stress levels are high, the perception of failure also increases, thus diminishing levels of self-efficacy. Further, Redmond (2010) describes physiological feedback as increased heart rate, increased body temperature, and feelings of agitation or anxiety. Anxiety over a given task can lead to decreased performance, and thus, decreased self-efficacy related to performance outcomes. Gregoire (2003) further explicates that negative physiological feedback can have debilitating effects on self-efficacy if the situation is perceived as a threat or a challenge (p. 163). This visceral response to perceived negative situations has been widely studied by the likes of Piaget (1980) and Vygotsky (1986). Piaget (1980) and then later Vygotsky (1986) postulated that a dual cognitive process occurs when presented with a perceived negative situation. More specifically, the response can be both a conscious and a subconscious response that can act as an, “affective and preconscious motivator in conceptual change” (p. 161). In response to this research, it is clear that mediating perceived difficult situations with multiple positive models throughout a teacher’s career may increase self-efficacy. As described earlier, modeling can be a way to increase self-efficacy. Positive modeling by an expert with clear outcome expectancy can be a vehicle for limiting emotional arousal and thus decreasing stress levels and increasing self-efficacy (Bandura, 1977).

In a longitudinal study investigating the self-efficacy of novice teachers at the beginning of their teacher preparation programs, at the end of student teaching, and after their 1st year as a classroom teacher, Hoy and Spero (2005) describe how perceptions of successes and/or failures can lead to changes in self-efficacy. They state, "The perception that one's teaching has been a failure lowers efficacy beliefs, contributing to the expectation that future performances will also be inept, unless the failure is viewed as providing clues about more potentially successful strategies" (p. 345). The effects of perceptions on self-efficacy beliefs can especially be true for novice teachers (Mulholland & Wallace, 2001). Further, if a success can be attributed to a controllable cause, as opposed to luck or intervention of others, then self-efficacy is enhanced (Pintrich & Schunk, 2001). The effects of physiological feedback seem to be the greatest source of changes, both positive and negative, in self-efficacy for teachers.

Verbal Persuasion

Verbal persuasion, primarily by a manager, can positively or negatively influence self-efficacy. Positive comments lead to increased self-efficacy and negative comments lead to decreased self-efficacy (Redmond, 2010). Bandura (1977) postulated that this might be true when people are told that they possess the attributes and skills necessary to perform a given task. Words of encouragement can persuade the receiver, even in the absence of skill, that they can perform a given task if they try hard enough. In the realm of education, the key providers of feedback are colleagues and the instructional leader or the principal. Further exploration of the role of the principal as instructional leader will be undertaken later in this literature review; however, Tschannen-Moran and McMaster (2009) state that specific verbal feedback from colleagues that encourages an individual can, "convince them that they can successfully implement a new teaching strategy" (p. 230). This is important to elementary teachers that may lack self-efficacy in teaching science because they often feel that they lack content knowledge to teach specific science concepts (Crawford, 2007).

Though a source of self-efficacy, studies have shown that verbal persuasion alone may not be a strong source of self-efficacy; however, when linked with the other sources of self-efficacy, it may provide the reinforcement necessary to encourage and even expand teaching skills (Tschannen-Moran & McMaster, 2009). Bandura (2001) further described the effects of verbal persuasion on self-efficacy:

> Social persuasion, though limited in its impact, may provide an "efficacy boost" to counter occasional setbacks that might have instilled enough self-doubt to interrupt persistence. The potency of persuasion depends on the credibility, trustworthiness, and expertise of the persuader. (p. 236)

Vicarious Experiences

Lived experiences are not the only source of perception of self-efficacy. Vicarious experiences, or learning through modeling, can lead to changes in self-efficacy. Specific to teaching, explicit absolute measures of adequacy do not exist and therefore, capabilities must be evaluated in relation to the performance of others (Bandura, 1997). If a colleague succeeds at a task, self-efficacy can increase. During an observation, if success is perceived, it can lead to the perception that the teaching task is manageable. Conversely, when the teaching model fails, the perception may be that the task is too difficult (Tschannen-Moran & McMaster, 2009). Thus, seeing multiple, successful, models increases self-efficacy and the opposite may detract from it. Teachers who believe in their ability will set more ambitious goals, and see the attainment of said goals as a challenge, not an obstacle (Bandura, 1997). Conversely, "teachers who believe that they will fail avoid expending effort because failure after trying hard threatens self-esteem" (Ross & Bruce, 2007, p. 51). This lies in the fact that modeled behavior without clear outcomes can lead to ambiguity in outcome expectancy for the observer (Bandura, 1977). A key strength of the Ross and Bruce (2007) study is the random assortment of control and treatment subjects in the experimental design (p. 57).

In summary, self-efficacy is an important influence on teaching practice (Ginns & Watters, 1999). Higher self-efficacy can result in increased expectations and thus a higher probability that difficult tasks will be viewed as challenges to overcome rather than insurmountable obstacles. A focus on the factors affecting self-efficacy can inform educational leaders on how to increase positive experiences in the classroom. Furthermore, there are four factors affecting self-efficacy: performance outcomes; physiological feedback; verbal persuasion; and vicarious experiences.

<u>Teacher Efficacy</u>

In their study examining the correlates of teacher efficacy using various instruments, Tsannen-Moran et al. (1998) described the multidimensional nature of self-efficacy (p. 228). As shown in Figure 3, teacher self-efficacy leads to increased performance and then increased cognitive processing, which in the end leads to increased self-efficacy. The same can be said of the cyclical nature of self-efficacy if self-efficacy is low (Figure 3). Most important to the discussion of teacher self-efficacy is its link to student outcomes (Tschannen-Moran & Hoy, 2002). These outcomes include student achievement (Allinder, 1995; Ashton & Webb, 1986; Goddard, Hoy, & Hoy, 2000), motivation (Mansfield & Woods-McConny, 2012), and students' sense of self-efficacy (Komarraju, 2013). In their study on the effects of teacher self-efficacy on student outcomes, specifically on student achievement, Goddard et al. (2000) report that every unit increase in a school's collective teacher self-efficacy scale score is associated with 8.62 and 8.49 point average gains in mathematics and reading achievement respectively (p. 501).

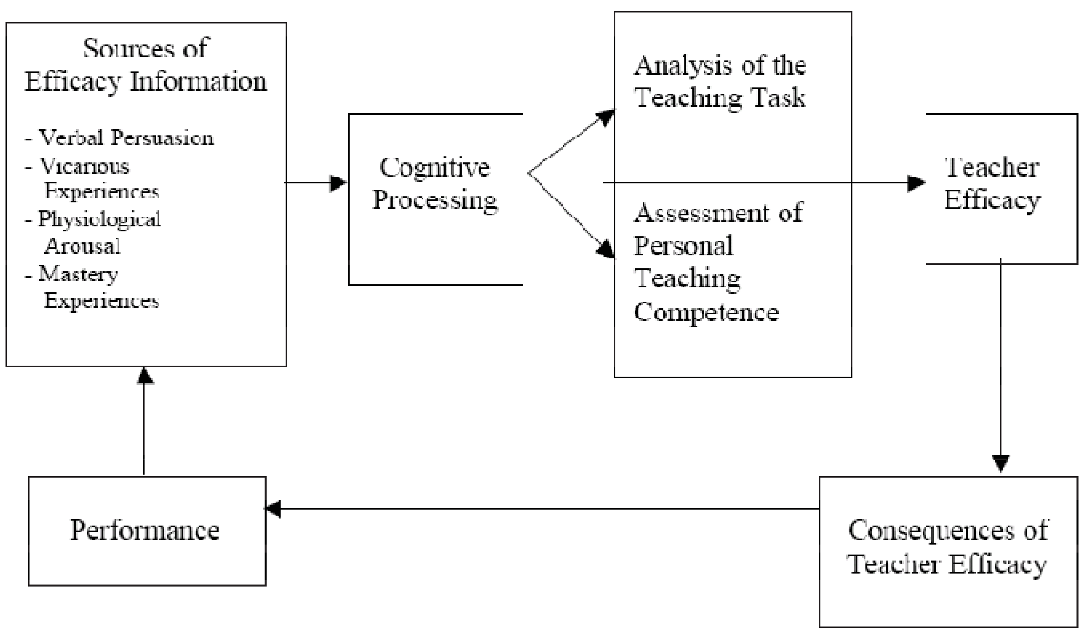

FIGURE 3. The nature of teacher self-efficacy. Adapted from Tchcannen-Moran, Woolfolk Hoy, & Hoy (1998, p. 228).

Their study included a total of 452 teachers from 47 schools. The results of their study are consistent with those of Bandura's (1993), which states, "Collective teacher efficacy perceptions are predictive of student achievement" (p. 141).

Self-Efficacy in Elementary Science Teaching

Bandura's (1977) social cognitive theory is a useful theoretical framework to explore the relationship between self-efficacy and elementary science teaching. Teachers with high levels of self-efficacy believe they will be able to engage in complex tasks and overcome them. They are able to set high goals and to persist in efforts to achieve said goals. Conversely, teachers with low self-efficacy tend to avoid perceived difficult tasks and disengage when faced with challenges (Mintzes, Marcum, Messerschschmidt-Yates, & Mark, 2012). This may explain why teachers with low self-efficacy in teaching science struggle with science content. The issue of low self-efficacy in teaching science may be attributed to two interdependent issues: science education is not a priority in the elementary setting and teacher preparation programs fail to prepare elementary teachers to adequately teach science (Wee, Shepardson, Fast, & Harbor, 2007).

The low priority placed on science in elementary education can be traced to NCLB, authorized by the Bush administration in 2001. NCLB narrowed the focus of education by increasing accountability standards that focused mainly on reading, writing, and mathematics. In March of 2010, President Obama proposed the "Blueprint for Reform of the Elementary and Secondary Education Act," attempting to address the issues created by NCLB (Duncan, 2010). Unfortunately, the proposed reform efforts continue to miss the mark of adequately preparing teachers and students to teach and learn science (Southerland, 2013). With the focus still clearly on reading, writing, and math, science education remains near the bottom of the list of subjects taught by elementary school teachers (Dorph et al., 2011).

While science education may not be a priority in the elementary setting, an even more pressing issue may be the lack of science preparation of teachers during pre-service instruction. Ginns and Watters (1999) predicted that teachers with low science teaching self-efficacy would avoid teaching science all together, or not implement curriculum that is in harmony with contemporary science education theory (p. 18). In their study, Ginns and Watters found that self-efficacy in teaching science of teachers in pre-service programs is as much a measure of their perceived confidence as it is their actual ability (p. 20). This research is important because providing pre-service teachers with robust science content, multiple positive models, and positive experiences may increase self-efficacy in teaching science prior to them even setting foot in their own classroom. Ginns and Watters add:

> A positive sense of self-efficacy requires the person concerned to believe that his or her previous experiences have been successful, that they can cope and are prepared to try in the face of setbacks. Without realistic feedback, pre-service teachers will not be able to perceive the effectiveness of their teaching behaviors and practice and, therefore, will not receive a stimulus to growth in their own confidence and expertise to teach science in an effective manner. (p. 22)

Later in their study, Ginns and Watters assert that, "science courses in pre-service programs must provide more authentic practices and experiences, and be the source of credible role models, for participants" (p. 22). The implications of this assertion are that pre-service programs must provide more content specific tasks as well as competent master teachers that can model high levels of self-efficacy in teaching science. The role of the master teacher will be discussed further herein.

These findings suggest that if teachers are uncertain about their ability to teach science, the quality of their instruction is diminished (Munby, Russell, & Martin, 2001), the quantity of their science instruction decreases (Druva & Anderson, 1983), and a dependency on text-based activities and narrow instructional practices are prevalent (Shymansky & Kyle, 1992). Unfortunately, these are realities given that a large portion of elementary school teachers, both in-service and pre-service, are ill prepared to teach science (Gess-Newsome, 2001).

Factors Affecting Teachers' Self-Efficacy in Teaching Science

The prominent literature regarding factors affecting self-efficacy specifically in teaching science centers around four key components: (a) teacher pre-service knowledge around science, (b) professional development, (c) interpersonal supports, and (d) principal instructional leadership. Of these factors, principal instructional leadership seems to have the greatest affect on teachers' sense of self-efficacy (Marzano, Waters, & McNulty, 2005).

Teacher Pre-Service Knowledge Around Science

Teacher pre-service knowledge is a key factor affecting self-efficacy (Ramey-Gassert, Shroyer, & Staver (1996). Teacher education, more specifically pre-service preparation programs consist of two main components: coursework in content and pedagogy and classroom instruction under the supervision of a master teacher. Research suggests that both pre-service course work and supervised classroom instruction must work in concert to increase self-efficacy in teaching science (Watters, Ginns, Enochs, & Asoko, 1995). This is especially true because teachers that are certified in the specific field that they teach are more likely to have a positive affect on student learning than those who are not (Darling-Hammond, 2010). An in-depth meta-analysis of 112 studies with an average of 120 participants conducted by E. A. Davis and Smithey (2009) explicates the importance of teacher education: "Within the subject of science, elementary teachers face further challenges, since at the elementary level teachers are responsible for life science, physical science, and earth science—and they are expected to teach these through engagement in authentic scientific practice" (p. 745).

Role of pre-service coursework. In a study by Meyer, Tabachnick, Hewson, Lemberger, and Park (1999), the development of three prospective elementary teachers was documented over the course of 2 years. Meyer et al. (1999) argued that the development of each prospective teacher varied greatly due to science background knowledge. Pre-service training and in-service assignments being constant, the determining variable was their science background knowledge. Their science background knowledge was influenced by prior knowledge gained during undergraduate studies and by new knowledge gained during pre-service science-content specific coursework. One of the three participants had an extensive science background, which proved to be the factor that led to observed benefits during in-service practice. The other two showed growth due to content knowledge gained during pre-service coursework. An obvious limitation of the study is the small sample size. This, however, is mitigated to some extent due to the length of the study. Documenting the progress of each participant over 2 years provided the researchers with multiple data measures and enabled them to conclude that while all three made progress in their science teaching, science background knowledge was the key factor of their development.

Much research has been conducted around the potential power of effective teacher preparation programs (Ferguson, 1991; Darling-Hammond, 2000; Louisiana Board of Regents, 2008; Wilson, Floden, & Ferrini-Mundy, 2001). A large-scale analysis of the New York City database found that some teacher preparation programs have a much more positive effect than others (Boyd, Lankford, Loeb, Rockoff, & Wyckoff, 2008). The study found that teacher certification is a significant predictor of student achievement. Similarly, Darling-Hammond (2010) found key features in exemplary programs. The key features include:

- Programs' careful oversight of the quality of student teaching experiences.
- The match between the context of student teaching and candidates' later teaching assignments, in terms of grade levels, subject matter, and type of students.
- The amount of coursework in reading and mathematics content and methods of teaching.
- A focus in courses on helping candidates learn to use specific practices and tools that are then applied in their clinical experiences.
- Candidates' opportunities to study the local district curriculum.
- A capstone project (typically a portfolio of work done in classrooms with students).
- Programs' percentage of tenure-line faculty, which the researchers viewed as a possible proxy for institutional investment and program stability. (p.40)

These findings are similar to Darling-Hammond's 2006 study that found, " . . . powerful teacher education programs have a clinical curriculum as well as a didactic curriculum" (p. 9).

Specific to science education, Ginns and Watters (1999) claim "science education courses need to have a stronger impact on the development of attitudes" (p. 19). The development of positive attitudes, specifically in science, can be achieved in part by providing pre-service teachers with authentic learning experiences that enhance self-efficacy. Additionally, providing positive peer and master teacher interactions can increase self-efficacy (Ginns & Watters, 1999).

Role of the master teacher. Wingfield, Freeman, and Ramsey (2000) report that self-efficacy can be positively affected when successful master teachers with appropriate science state licensures train new teachers. One limitation of the study conducted by Wingfield et al. is the small sample size (n = 31) and the relatively limited time over which the study was conducted (1 school year). The role of teacher preparation programs, more specifically, master teachers, in providing pre-service teachers with positive experiences that may increase self-efficacy in teaching science is explained by Ginns and Watters (1999):

> In particular, teachers who have high levels of personal science teaching self-efficacy and have already experienced success in teaching science in elementary schools should be appointed as mentors for beginning teachers. While university science teacher educators must be aware of, and support, pre-service teachers' ability to cope with practical experiences in science and science teaching and design courses to either maintain or enhance their sense of self-efficacy, it is vital that similar support mechanisms continue into the induction year of teaching and beyond. (p. 20)

Teacher education is a key component of self-efficacy in teaching science. Along with pre-service teachers, in-service teachers require continual skill and content development to increase self-efficacy in teaching science. There is much research supporting the importance professional development on in-service teachers' sense of self-efficacy in teaching science.

Professional Development

There is an extensive body of research on the positive effects of professional development in the areas of content knowledge, beliefs, and practice (Akerson & Hanuscin, 2007; Bell & Gilbert, 1994; Buczynski & Hansen, 2010; Grigg, Kelly, Gamoran, & Borman, 2013; Johnson & Fargo, 2010). Because classroom instruction is the number one influence on student achievement (Wahlstrom et al., 2010), it is important that teacher learning leading to positive change in teaching practices occur (Borko, 2004). In their findings from a longitudinal study, Supovitz and Turner (2000) show dramatic results when, "[professional development] experiences were deeper and more sustained" (p. 975). This study took place over a 2-year period and included survey data from 24 different communities across the United States. In total, the study included data from 3464 teachers and 666 principals in 24 localities (Supovitz & Turner, 2000). Regardless of the type, quality, or quantity of professional development, support for teacher learning is essential (Crawford, 2007).

Posnanski (2002) asserts that as knowledge of specific teaching strategies and of subject matter increase, self-efficacy increases. As with much of the literature on science related professional development, this study consisted of an in-service training model that was brought to a school district to train all of the elementary teachers in the district. The model itself was comprised of research-based methods and materials developed by experts from the Biological Science Curriculum Study (BSCS). The author concluded that the professional development series was effective in increasing teachers' sense of self-efficacy in teaching science. The study included a pre- and post-professional development survey as well as post-professional development interviews. The researcher's use of mixed methods provides triangulation of the data and increases validity.

In her study of the experiences of middle school science teachers who participated in a collaborative standards-based professional development series, Johnson (2007) found that even with extensive professional development, teachers' implementation of standards-based instructional practices varies at multiple levels. One shortcoming of the study was that it only included data from two schools in a small Southeastern town. Though the sample size was small, the findings of this study are not dissimilar from other like studies. In a larger 3-year study of the effects of inquiry-based professional development on 73 schools in the greater Los Angeles area, Grigg et al. (2013) found the impact of professional development was limited to selected features of the methods teachers were exposed to during the professional development. They concluded that while teaching practice was changed due to the professional development series, the change was limited to lessons directly taught during the professional development series (p. 51).

In terms of which types of professional development are most appropriate to improve science teaching practice, current literature is inconclusive. Further, while research on the positive effects of professional development on teacher self-efficacy abounds, research focused on science professional development is less positive (Buczynski & Hansen, 2010). There are many reported barriers to effective professional development, including a general lack of science specific professional development. In their report on science education in California, Dorph et al. (2011) synthesized findings from multiple sources, including district administrator and teacher surveys, case studies of elementary schools, and data sets available through statewide databases. The study found that, "over 85% of elementary teachers have not received any science-related professional development in the last three years" (p. 26). This general lack of support for science instruction is a contributing factor to deficiencies in teachers' sense of self-efficacy in teaching science.

Types of professional development. Research describes many types of professional development available to in-service teachers: traditional, horizontal learning, and online. While there is much research on these three types of professional development, there is a lack of research dedicated specifically to STEM professional development. Of the three types of professional development, traditional professional development is most prevalent. Traditional professional development usually entails single or multiple day workshops at which teachers are given information (Avery, 2010). These short-term professional development sessions lack key characteristics of effective professional development. Namely, they lack the sufficient duration and depth of knowledge to be effective (Shields, Marsh, & Adelman, 1998). Further, traditional professional development sessions rarely focus on the ways in which students learn science and math content, specifically with regards to students' conceptual understanding (D. K. Cohen & Hill, 1998).

Another type of professional development described in the research is horizontal learning. This type of professional development relies on learning from peers and professional networks. A key strength of this method of professional development is its ongoing nature. This type of continuing professional development is key to the development of both procedural and declarative knowledge (Knight, 2002). Knight's (2002) work was developed based on Shulman's (1987) seven sorts of teaching knowledge. Shulman (1987) describes the need for both procedural and declarative knowledge in teaching:

1. Content knowledge - Mathematics, Science, Art, Geography, etc.
2. General pedagogical knowledge - knowledge of principles and strategies for curriculum and class management in general.
3. Curriculum knowledge - knowledge of the materials and programs that are the tools of the trade.
4. Pedagogical content knowledge - a ". . . special amalgam of content and pedagogy . . . [teachers'] own special form of professional understanding."
5. Knowledge of learners and their characteristics.
6. Knowledge of educational contexts - of the characteristics and effects of groups, classrooms, school district administration, communities and cultures.
7. Knowledge of ". . . educational ends, purposes, and values and their philosophical and historical grounds." (Shulman, 1987, p. 8)

While Knight's (2002) and Shulman's (1987) work provide a strong argument for the type of professional development needed to support teachers' efforts, they lack a general sense of how this might look in a practical model. Addressing the needs of the adult learner is ever important; however, with time and monetary constraints, this model is less efficient than others.

The third type of professional development described in the literature is online learning. This is a relatively new form of professional development and less research is available on the subject. However, in a robust experimental design study, Fishman et al. (2013) compared online professional development and face-to-face professional development to see which model produced greater teacher learning and student performance outcomes. The findings of the study indicated that with both models of professional development there were significant gains made by students and teachers alike. Thus, there were no significant differences between the two conditions. These findings are significant in that online models of professional development are promising and may be a more efficient and cost-effective mode of professional development for teachers (Fishman et al., 2013).

Interpersonal Supports

Interpersonal support among teachers seems to be a main factor on self-efficacy in teaching (Tschannen-Moran & Hoy, 2007). In their quantitative study of 255 novice teachers, Tschannen-Moran and Hoy (2007) found that interpersonal support of colleagues made significant contributions to teachers' self-efficacy. Further, the study found that interactions between colleagues had a more significant influence on self-efficacy than interactions between administrators and teachers (Tschannen-Moran & Hoy, 2007, p. 954). A shortcoming of this study is the relative isolation in which the study was conducted. The study employed a one-time survey of relatively new teachers taking a graduate level methods course at a state university. By the researchers' own admission, “longitudinal designs would allow researchers to observe the periods of flux and stability of self-efficacy beliefs at different career stages” (Tschannen-Moran & Hoy, 2007, p. 954).

In another study on the affects of interpersonal support among teachers, Hoy and Spero (2005) found that support from colleagues correlated positively with changes in self-efficacy (p. 352). Hoy and Spero state, “when this support was withdrawn, efficacy fell” (p. 353). Thus interpersonal support systems created by teachers are an important factor affecting self-efficacy. The study does point out that creating these teacher support structures can be difficult because finding time to collaborate is not in the teachers’ control. The principal is responsible for creating schedules and, thus, is in control of collaboration time. This study showed it is important that the instructional leader make time for teacher collaboration as it is shown to increase self-efficacy in teaching science.

Principal Leadership

Principal instructional leadership has been shown to positively influence teacher practice (Murphy, 1998). Wahlstrom et al. (2010) state that, “leadership is second only to classroom instruction among school-related factors that affect student learning in school” (p. 3). As an integral part of teaching and learning, the principal must build internal capacity by making “a major commitment to individual professional development” (Sebring & Bryk, 2000, p. 4). As the instructional leaders of a school, principals set the tone of the teaching going on at their school. They set the agenda for teaching and learning. It is the responsibility of the principal to guide teachers as to what is important for them to teach and how instructional minutes should be spent in the classroom. The principal has a major role in deciding whether or not science is a priority in his or her school.

The principal can also have a major influence on teacher self-efficacy. Using a comparative case study design, Hipps (1997) interviewed and observed 280 middle school teachers regarding the relationship between self-efficacy and principal leadership. Through interviews, observations, and field notes, five leader behavior themes emerged as having a positive effect on teacher self-efficacy. The five leader behavior themes include: modeling the desired behavior, inspiring the group, providing contingent rewards, holding high performance expectations, and providing support (Hipps, 1997). Further research supports the direct and indirect effects of leadership on teacher self-efficacy (Ross & Gray, 2007).

In an extensive research study, Ross and Gray (2007) collected data from over 3,000 teachers in 218 elementary schools. An analysis of the data found that transformational leadership had direct and indirect effects on teacher self-efficacy. For the purposes of the study, they defined transformational leadership as, "dedication to fostering the growth of organizational members and enhancing their commitment by elevating their goals" (Ross & Gray, 2007, p. 4). The study included the use of three validated instruments to measure the correlation between transformational leadership and (a) teacher self-efficacy and (b) teacher commitment. Strong quantitative cross-validation methods were used to analyze the data. The findings showed a strong correlation between transformational leadership and teacher self-efficacy. Further, teacher commitment was indirectly affected by teacher self-efficacy. Thus, the transformational leader was capable of directly increasing self-efficacy and indirectly increasing teacher commitment. This study is supported by its large sample size and use of cross-validation sample method (Ross & Gray, 2007).

Further, in a broad quantitative analysis, Calik, Sezgin, Kavgachi, and Kilinc (2012) surveyed 328 classroom teachers on the influence of principal instructional leadership on their self-efficacy. Multiple validated scales were utilized and structural equation modeling was implemented to test the model. The research findings indicated that principal instructional leadership had a significant direct and positive impact on collective teacher efficacy ($\beta = .13$, $p < .05$). The implications of the study are important because teacher perception of strong instructional leadership can play a significant role in teacher self-efficacy (Calik et al., 2012, p. 2500).

Summary of the Literature

A thorough review of the literature focused on the factors affecting self-efficacy in teaching science at the elementary level. Self-efficacy is an important influence on teaching practice. Self-efficacy is defined as "peoples' judgment on their capabilities to organize and execute courses of action required to attain designated types of performances" (Bandura, 1986, p. 391).

The research pointed towards four main factors that affect self-efficacy: (a) performance outcomes, (b) physiological feedback, (c) verbal persuasion, and (d) vicarious experiences. Of the four domains, performance outcomes may have the most effect of self-efficacy. Verbal persuasion has the smallest effect on self-efficacy; however, when coupled with positive principal instructional leadership, they can be strong tools to increase self-efficacy. Further, the literature provided four main factors that affect self-efficacy in teaching science: (a) professional development, (b) teacher education, (c) interpersonal supports, and (d) principal instructional leadership.

In looking for examples of the four factors affecting self-efficacy in teaching science, bright spots were found. The studies focusing on these bright spots illuminated both the positive affects of the four factors as well as the general lack of inclusion of the four factors within the educational community. The positive effects of professional development are well documented (Akerson & Hanuscin, 2007; Bell & Gilbert, 1994; Buczynski & Hansen, 2010; Grigg et al., 2013; Johnson & Fargo, 2010); however, there is a general lack of support for science related professional development (Dorph et al., 2011). A focus on the type and the length of professional development was key in the research. The three types of professional development explained in the research (traditional, horizontal learning, and online) each have their strengths and weaknesses. Online professional development seems to be promising as it encompasses the key components of effective professional development. These key components consist of targeted, purposeful, and ongoing professional development (Supovitz & Turner, 2000). Further, online professional development may be more efficient and cost effective than other modes of professional development (Fishman et al., 2013).

The research also points towards a lack in pre-service training in the area of science education (Akerson & McDuffie, 2002). The last two factors, interpersonal supports and principal instructional leadership are interrelated. The literature postulates that interpersonal supports are important for effective science instruction; however, many leaders do not provide time in the schedule for science collaboration (Hoy & Spero, 2005). Aside from providing collaboration time, the principal instructional leader may increase teacher self-efficacy through transformational leadership (Ross & Gray, 2006). The role of the principal has evolved in recent years and a strong relationship between teacher perception of a strong instructional leader and increased self-efficacy is present (Calik et al., 2012).

In conclusion, recent education policies have caused a gap in teacher and student learning with respect to science education. Teacher preparation programs have also suffered due in part to education policies focusing primarily on reading, writing, and math. Both in-service and pre-service teachers need specific science professional development to combat the deficiencies that are present in America today. There are various implications that could shape policy and practice on the macro and the micro levels. Policy makers and practitioners alike are encouraged to expand science pedagogy taught in teacher preparation programs. Current reforms have stressed the importance of, but have missed the mark of improving science instruction at the elementary level (Southerland, 2013). The charge to improve science education starts with the education of teachers during pre-service training programs. Further reform is needed to ensure that effective science instruction is a priority at all levels of education. Along with teacher preparation programs, professional development creators are tasked with the responsibility to create effective professional development models that will increase self-efficacy, and thus effectiveness of science teaching practices. On the micro level, instructional leaders need to implement programs that allow teachers time for collaboration. The need for increased investments in teacher professional development, specifically in science, is paramount to increase self-efficacy in teaching science. Further research on the factors positively affecting self-efficacy in teaching science can help teacher education programs, professional development creators, and instructional leaders' aide teachers in the implementation of more effective science programs nationwide.

CHAPTER 3

METHODOLOGY

Introduction

Social cognitive theory suggests that individuals tend to select tasks and activities in which they feel competent and confident, and avoid those in which they do not (Bandura, 1986). In this study, I used social cognitive theory as a theoretical framework because it can be a model for the actions that people take, the effort that they put into a task, and can be a predictor of motivating factors. The purpose of this dissertation study was to explore the experiences of elementary school master teachers as they participated in a 2-year grant funded STEM-rich professional development. More specifically, the study explored the effects of the STEM-rich professional development on elementary teachers' sense of self-efficacy in teaching science. The study also examined the background variables that might affect elementary teachers' sense of self-efficacy in teaching science.

The stories of the elementary school master teachers were recorded in an explanatory mixed-methods format to draw on strengths of both quantitative and qualitative methodologies. According to Creswell and Clark (2010), "Researchers conduct mixed methods studies when both quantitative and qualitative data, together, provide a better understanding of the research problem than either type by itself" (p. 299).

Research Questions

This study addressed the following research questions:

1. Is there a difference in self-efficacy between the teachers that participated in the STEM professional development and teachers that did not participate in the STEM professional development?

2. To what extent do other factors influence elementary teacher's sense of self-efficacy in teaching science? Specifically, which, if any, of the following factors influence self-efficacy?

a. Teacher Pre-Service Knowledge Around Science.

b. Professional Development.

c. Interpersonal Supports.

d. Principal Instructional Leadership.

3. What aspects of the STEM-rich professional development most contributed to teachers' sense of self-efficacy in teaching science?

Research Design

The study design utilized was an explanatory mixed methods design (Figure 4). This consisted of, first, gathering and analyzing quantitative data, and then collecting and analyzing qualitative data to elaborate and add depth to the quantitative data. Creswell and Clark (2010) describe the explanatory design as a means to, "capture the best of both quantitative and qualitative data to obtain quantitative results from a population in the first phase, and then refine or elaborate these findings through an in-depth qualitative exploration in the second phase" (p. 305). The initial phase of the study included a simple descriptive survey, which consisted of 25 questions with responses ranging from strongly agree to strongly disagree. In this first phase, the entire sample was asked to complete the survey. The second phase of the study included both a semi-structured, open-ended focus group and two semi-structured, open-ended individual interviews. The main purpose for collecting interview data was to have a deeper understanding of the specific factors that influence elementary teachers' sense of self-efficacy in teaching science. All of the participants that completed the survey were asked to self-select to participate in the focus group interview. The two methods were then integrated in the interpretation of the data.

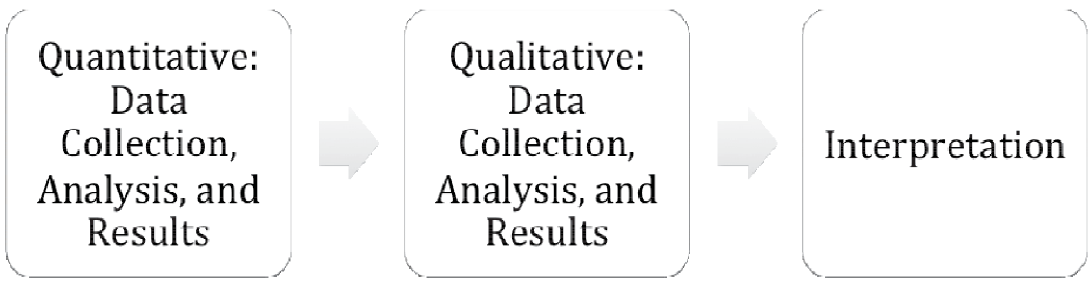

FIGURE 4. The explanatory mixed methods design. Creswell and Clark (2010, p. 304).

The explanatory mixed methods design was embedded in an overarching quasi-experimental design. A quasi-experimental design allows researchers to utilize intact groups of participants while still manipulating the conditions that are experienced by the groups (Creswell & Clark, 2010, p. 170). This design was achieved by comparing an experimental group and a control group during the quantitative and qualitative data collection processes. The treatment group consisted of master teachers participating in a 2-year STEM professional development. The control group consisted of master teachers that did not participate in the 2-year STEM professional development series. Thus, the treatment was the STEM professional development. The researcher measured the dependent variable (self-efficacy) and the control variable (master teacher for a minimum of 5 years) from the participants both participating in and not participating in the STEM professional development. The variables were assessed before the treatment (pre-test) and then again after the treatment (post-test).

Data Collection Methods

Two different yet complimentary data collection methods were used for this study. First, quantitative data were gathered by administering surveys to participants. Next, qualitative data were gathered by, first, asking participants to self-select to participate in a focus group interview, and second, by interviewing two of the student teacher coordinators who frequently interacted with master teachers in the treatment group. Both quantitative and qualitative procedures were developed using rigorous standards. Both quantitative and qualitative data were collected and analyzed with the same rigor so that one data source did not overpower the other (Brannen, 1992).

Quantitative: The Survey

The survey instrument utilized in this study was STEBI, which was developed by Enochs and Riggs (1990; Appendix A). Specifically designed for elementary school teachers, the survey approximates teachers' sense of self-efficacy in teaching science. The instrument consists of two categories of questions: personal science teaching efficacy (PTSE) and science teaching outcome expectancy (STOE). The PTSE portion of the instrument measures the level of belief that elementary school teachers have that they can teach science. The STOE portion of the instrument measures the effect the teachers feel they will have on their students. The instrument uses a 5-point Likert scale consisting of 25 questions, with responses ranging from strongly disagree (1) to strongly agree (5). The instrument was specifically designed to assess science-teaching efficacy of elementary school teachers. A reliability analysis of the PTSE and the STOE was carried out, which showed factor loadings of 0.92 and of 0.77 respectively (Enochs & Riggs, 1990, pp. 625-637). Enochs and Riggs (1990) state that, "items correlated highly among themselves. Correlations between the two dimension's items, however, were not as high. This pattern indicates homogeneity within the distinctiveness between the scales, and enhances construct validity" (p. 632). On the survey, positively worded items were scored positively while negatively worded items were scored in the opposite direction (example: Positively worded item: Strongly Agree = 5; Negatively worded item: Strongly Disagree = 5).

Synthesis of Literature Review, Research Question, and Instrument Question Number

In an attempt to strengthen content validity, I constructed a synthesis of the relevant literature, the independent variables, and the survey question numbers. Table 3 illustrates the links between the independent variables, the survey question numbers, and the relevant literature in this study.

Qualitative: The Focus Group Interview

After participants responded to the 25 survey questions, a follow-up focus group was conducted to further analyze the survey results and to add validity through triangulation to look for convergence in the research findings (Greene, 2007). To encourage participation in the focus group interview, survey participants were asked to self-select into the focus group portion of the study. All participants that responded positively to the invitation were admitted into the focus group interview. A focus group was chosen because of the dynamic interaction produced within the group, which is also known as “the group effect” (Carey, 1994; Morgan, 1996). Morgan (1996) states,

> What makes the discussion in focus groups more than the sum of individual interviews is the fact that the participants both query each other and explain themselves to each other. . . . [S]uch interaction offers valuable data on the extent of consensus and diversity among participants. (p. 139)

TABLE 3. Synthesis of Literature Review, Independent Variable, and Instrument Question Number

Independent Variable	Survey Question Number	Relevant Literature
Personal Science Teaching Efficacy (PSTE)	2, 3, 5, 6, 8, 12, 17, 18, 19, 21, 22, 23, 24	Bandura (1977, 1982, 1997), Redmond, (2010), Ross (1994), Schunk (1985), Ginns and Watters (1999), Pontius (1998), Enochs & Riggs (1990), Woolfolk-Hoy & Kolter-Hoy (2006).
Science Teaching Outcome Expectancy (STOE)	1, 4, 7, 9, 10, 11, 13, 14, 15, 16, 20, 25	Bandura (1977, 1982, 1997), Redmond, (2010), Ross (1994), Schunk (1985), Ginns and Watters (1999), Pontius (1998), Enochs & Riggs (1990), Woolfolk-Hoy & Kolter-Hoy (2006).

The questions on the interview protocol (Appendix B) further added to the depth of understanding that the researcher was able to gain from the participants. The questions also focused on other key factors found in the literature regarding elementary teachers' self-efficacy in teaching science. The interview protocol was piloted prior to introduction to the participants to gain important information about the protocol prior to using it with the target population. Jacob and Ferguson (2012) state, "It is a good idea to pilot your test questions to make sure they are clear" (p. 5). The focus group interviews added valuable information that the survey data could not provide, adding to the depth and complexity of the data collected. Further, the focus group interviews gave participants the opportunity to further explore their own self-efficacy in teaching science.

Synthesis of Literature Review, Research Question, and Instrument Question Number for Focus Group Interview Protocol

One way to strengthen content validity is to be self-reflective about the research protocols (Creswell & Clark, 2010). To that end, the researcher created a table showing the links between the research questions, the protocol questions, and the relevant literature on the subject. Table 4 illustrates the links between the research questions, the interview questions, and the relevant literature in this study.

Qualitative: University Student Teacher Coordinator Interviews

The questions on the interview protocol (Appendix C) further added to the depth of understanding that the researcher was able to gain from the participants. The questions focused on the perceptions of the university student teacher coordinators with respect to self-efficacy. Again, the questions were derived from the literature and they aimed at strengthening the data so as to help answer the three research questions (Table 5).

TABLE 4. Synthesis of Literature Review, Research Question, and Instrument Question Number for Focus Group Interview Protocol

Research Question	Interview Question Number	Relevant Literature
2	1	Bandura (1977, 1982, 1997), Tschannen-Moran, Hoy, & Hoy (1998).
2	2	Buczynski & Hansen (2010), Mulholland, & Wallace (2001), Settlage, Southerland, Smith, & Ceglie (2009), Cakiroglu, Capa-Aydin, & Hoy (2012), Ross, (1994), Woolfolk Hoy & Spero (2005), Wee, Shepardson, Fast, & Harbor (2007).
2	3	Tschannen-Moran, & Hoy (2007), Friedman (2003).
2	4	Hallinger, & Heck (2002), O'Donnell & White (2005), Murphy (1998), Sebring & Bryk (2000), Hipps (1997).
1 & 2	5	Posnanski (2002), Akerson & Hanuscin (2007), Bell & Gilbert (1994), Buczynski & Hansen, (2010), Grigg, Kelly, Gamoran, & Borman (2013), Johnson & Fargo (2010). Ross & Gray (2007).
1 & 2	6	Posnanski (2002), Akerson & Hanuscin (2007), Bell & Gilbert (1994), Buczynski & Hansen, (2010), Grigg, Kelly, Gamoran, & Borman (2013), Johnson & Fargo (2010). Ross & Gray (2007).

TABLE 4. Continued

Research Question	Interview Question Number	Relevant Literature
1 & 2	7	Bandura (1977, 1982, 1997), Redmond, (2010), Ross (1994), Schunk (1985), Ginns and Watters (1999).
1 & 2	8	Bandura (1977, 1982, 1997), Redmond, (2010), Ross (1994), Schunk (1985), Ginns and Watters (1999).
1 & 2	9	Bandura (1977, 1982, 1997), Redmond, (2010), Ross (1994), Schunk (1985), Ginns and Watters (1999).
1 & 2	10	Bandura (1977, 1982, 1997), Redmond, (2010), Ross (1994), Schunk (1985), Ginns and Watters (1999).

Synthesis of Literature Review, Research Question, and Instrument Question Number for Student Teacher Coordinator Interview Protocol

As with the focus group interviews, the researcher created a table showing the links between the research questions, the protocol questions, and the relevant literature on the subject for the student teacher coordinator interviews. Table 5 illustrates the links between the research questions, the interview questions, and the relevant literature in this study. This was done in an attempt to strengthen the validity of the interview protocol.

Participants

The participants in this study were selected from two different groups and had to meet specific criteria. Both groups of participants were master teachers that were working with or that have worked with student teachers in the past 5 years. The criterion that master teachers had to have worked with student teachers in the past 5 years was so that both the treatment and control groups were similar.

<u>Treatment Group</u>

The treatment group of master teachers was selected because they were participating in a 2-year STEM professional development. The professional development series focused specifically on STEM content knowledge and pedagogy. This group took both a pre-survey and a post-survey. All of the participants in this group were elementary school teachers that worked in an urban setting with a diverse group of students (n = 25). Table 6 shows a demographics table of each participant in the treatment group.

<u>Control Group</u>

The control group was similar to the treatment group in that they were serving as, or had served as master teachers in the past 5 years (n = 25). This group of participants did not participate in the STEM professional development. This group only took one survey, as they did not participate in the professional development. Like the treatment group, all of the participants in this group were elementary school teachers that worked in an urban setting with a diverse group of students. Initial differences between the treatment and control groups were controlled and an independent samples t-test was run to compare the post-test of the control group and the post-test of the treatment group. Table 7 shows a demographics table of each participant in the control group.

<u>University Student Teacher Coordinators</u>

The university student teacher coordinators were solicited to participate in this study to add a layer of data from the point of view of a university coordinator. The university student teacher coordinators worked directly with students that were

TABLE 5. Synthesis of Literature Review, Research Question, and Instrument Question Number for Student Teacher Coordinator Interview Protocol

Research Question	Interview Question Number	Relevant Literature
2	1	Bandura (1977, 1982, 1997), Tschannen-Moran, Hoy, & Hoy (1998).
3	2	Buczynski & Hansen (2010), Mulholland, & Wallace (2001), Settlage, Southerland, Smith, & Ceglie (2009), Cakiroglu, Capa-Aydin, & Hoy (2012), Ross, (1994), Woolfolk Hoy & Spero (2005), Wee, Shepardson, Fast, & Harbor (2007), Supovitz & Turner (2000).
3	3	Tschannen-Moran, & Hoy (2007), Supovitz & Turner (2000), Friedman (2003).
3	4	Hallinger, & Heck (2002), O'Donnell & White (2005), Murphy (1998), Sebring & Bryk (2000), Hipps (1997), Supovitz & Turner (2000).
1 & 2	5	Posnanski (2002), Akerson & Hanuscin (2007), Bell & Gilbert (1994), Buczynski & Hansen, (2010), Grigg, Kelly, Gamoran, & Borman (2013), Johnson & Fargo (2010). Ross & Gray (2007).
1, 2, & 3	6	Posnanski (2002), Akerson & Hanuscin (2007), Bell & Gilbert (1994), Buczynski & Hansen, (2010), Grigg, Kelly, Gamoran, & Borman (2013), Johnson & Fargo (2010), Ross & Gray (2007), Supovitz & Turner (2000).

TABLE 5. Continued

Research Question	Interview Question Number	Relevant Literature
1, 2, & 3	7	Bandura (1977, 1982, 1997), Redmond, (2010), Ross (1994), Schunk (1985), Ginns and Watters (1999), Supovitz & Turner (2000).
1 & 2	8	Bandura (1977, 1982, 1997), Redmond, (2010), Ross (1994), Schunk (1985), Ginns and Watters (1999).
3	9	Bandura (1977, 1982, 1997), Redmond, (2010), Ross (1994), Schunk (1985), Ginns and Watters (1999), Supovitz & Turner (2000).
3	10	Bandura (1977, 1982, 1997), Redmond, (2010), Ross (1994), Schunk (1985), Ginns and Watters (1999), Supovitz & Turner (2000).

participating in the student teaching portion of the credential program. While their main focus was on the student teachers, they also had an ongoing relationship with the master teachers with whom their student teachers worked. The supervisors also participated in the implementation of the STEM-rich professional development. Their unique point of view was captured via individual interviews, which focused on the perceptions of the university student teacher coordinators with respect to self-efficacy.

TABLE 6. Demographic Table of Participants in Treatment Group

Participant Number	Current Grade Taught	Total Years Teaching
1	2	11
2	2	19
3	$4^{th}/5^{th}$	12
4	2	20
5	2	29
6	5	13
7	4	14
8	2	13
9	TK	19
10	5	5
11	3	12
12	5	10
13	4	17
14	3	17
15	TK	24
16	5	14
17	1	19
18	1	14
19	$4^{th}/5^{th}$	5
20	2	5
21	5	18
22	1	15
23	5	17
24	4	16
25	2	17

TABLE 7. Demographic Table of Participants in Control Group

Participant Number	Current Grade Taught	Total Years Teaching
1	5	15
2	3rd/4th	13
3	5	20
4	TK	18
5	Pre-K	20
6	5	25
7	4th/5th	13
8	4	32
9	1	18
10	3	29
11	K	17
12	2nd/3rd	28
13	1	8
14	1	20
15	2	17
16	K	19
17	2	33
18	K	17
19	4	15
20	5	13
21	K	25
22	5	13
23	3rd/4th	15
24	K	15
25	5	14

Procedures

Phase 1: Quantitative Treatment Group

All of the participants in the treatment group were members of the STEM professional development. As part of participation in the STEM professional development, all participants signed an informed consent form (Appendix C). All participants were asked to fill out the STEBI survey instrument prior to the beginning of the professional development series (pre-test) and after the professional development series (post-test). These participants filled out a paper version of the survey. Participants were told that they were not required to answer any question that they did not feel comfortable answering. The surveys were collected and the researcher entered the data manually.

Phase 2: Quantitative Control Group

After receiving IRB approval from all institutions involved, all of the participants were contacted via email (Appendix-D). For ethical reasons, permission to conduct research was sought prior to contacting the participants. The email that was sent to each participant contained an active link to the online survey (Appendix E). An online survey was chosen for both security and for ease of access to participants. The researcher also chose to use an online survey in the hopes that in would increase response rates. The first page of the online survey gave specific instructions for completing the survey. It also included assurances for the level of security and confidentiality that participants could expect. The survey was administered through the “Survey Monkey” website, which is both secure and efficient. This method ensured ease of access to participants as well as ease of analysis for the researcher. Participants were not required to answer questions that they did not feel comfortable answering and they were able to review all answers prior to final submittal of the survey.

Phase 3: Qualitative Treatment and Control Groups

The second phase of the study included an in-depth focus group interview of all participants that responded positively to the survey question asking for their participation (treatment group $n = 9$, control group $n = 7$). The treatment group was asked during the final professional development session if they would be willing to participate in a focus group interview (Appendix F). All those that responded positively were asked to participate in the focus group interview. The control group was asked for their participation at the end of the online survey. All those that responded positively were asked to participate in the focus group interview. After the participants were secured, two focus group sessions were held: one for the treatment group and one for the control group. Each participant was asked to sign an informed consent form prior to the commencement of the focus group (Appendix G). The informed consent included a clause allowing the researcher to audio record the entire focus group interview. All participants were informed that if even one of them did not want to be audio recorded that they would still be allowed to participate and that the focus group would not be recorded. All participants in both groups agreed to allow the researcher to audio record the focus group interviews.

The researcher conducted the two focus group interviews. The focus group interviews were audio recorded and the researcher took notes as well. The audio-recorded focus group interviews were transcribed and members of the focus group were offered the opportunity to read the transcripts to check for accuracy of their responses. After transcription, qualitative coding methods were used to code the data. Both quantitative and qualitative data sets were then integrated and analyzed. Triangulation of the data was achieved through this method and added to a richer understanding of the data (Creswell & Clark, 2010).

Data Analysis

The quantitative data was analyzed using SPSS to conduct a paired-samples *t*-test and an independent samples *t*-test. A paired samples *t*-test is used when; "the mean of one sample is compared to the mean of another sample, where the two samples are related in some way" (Yockey, 2011). Thus, a paired samples *t*-test was run to see if there was an increase in self-efficacy in teaching science for the participants in the STEM professional development. To accomplish this, the pre- and post-surveys were compared and analyzed using a paired samples *t*-test. The second test was an independent samples *t*-test. Yockey (2011) explained that an independent samples *t*-test is used, "when the means of two independent groups are compared on a continuous dependent variable of interest" (p. 71). The post-survey of the control group was compared to the post-survey of the treatment group.

Hypothesis—Independent Samples *t*-Test

The two groups described in this study were those that participated in the STEM professional development (experimental) and those that did not participate in the STEM professional development (control). The null hypothesis was that there would be no difference in the self-reported level of self-efficacy in teaching science between the two groups. The alternate hypothesis was that there would be a significant difference in the self-reported self-efficacy in teaching science between the two groups. The mean and standard deviations were compared and significance was determined by a *p*-value less than .05.

Hypothesis—Paired Samples *t*-Test

The treatment group was compared against itself, comparing the pre-survey and the post-survey. The null hypothesis was that there would be no difference in the self-reported level of self-efficacy in teaching science between the pre-survey and the post-survey. The alternate hypothesis was that there would be a significant difference in the self-reported self-efficacy in teaching science between the pre-survey and the post-survey. The mean and standard deviations were compared and significance was determined by a *p*-value less than .05.

After each focus group interview, the recordings were transcribed and the researcher began the iterative process of coding. This iterative process included both decoding and encoding of the transcripts. Saldaña (2013) stated, " . . . when we reflect on a passage of data to decipher its core meaning, we are *de*coding; when we determine its appropriate code and label it, we are *en*coding" (p. 5). This iterative process was conducted using a three-cycle method approach (Yockey, 2011). During the first cycle, NVivo and an open coding method were used to look for emerging themes. The second cycle also included the use of NVivo; however, during this cycle, more in-depth pattern coding was utilized. During this cycle, the theoretical framework was utilized as the lens for coding. More specifically, the four domains of self-efficacy were utilized during the second cycle:

1. Performance Outcomes.
2. Physiological Feedback.
3. Verbal Persuasion.
4. Vicarious Experiences.

During the third cycle of coding, the four factors from research Question 2 were utilized. The four factors were:

1. Teacher Pre-Service Knowledge Around Science.
2. Professional Development.
3. Interpersonal Supports.

4. Principal Instructional Leadership.

Coding of the data yielded major themes with multiple codes related to each theme. Salnaña (2013) states "coding is not a precise science; it is primarily an interpretive art" (p. 4). The researcher consolidated codes on multiple occasions until saturation occurred and until new codes did not emerge. The outcomes of this coding were themes, which were an analytic reflection of the sum of the codes (Salnaña, 2013, p. 14). In an effort to increase trustworthiness of the analysis of the findings, the researcher engaged in peer debriefing of the proposed themes and codes. Peer debriefing took place at multiple points during the coding process. The coding process and subsequent themes that emerged were used to make broad and general conclusions about elementary teachers' sense of self-efficacy in teaching science. Another measure taken to ensure trustworthiness was listening to the audio recordings multiple times. After listening to the recordings multiple times, both pre- and post-transcription, the transcripts were read and re-read. Finally, the codes and themes were consolidated multiple times and peer debriefing was employed to check final codes.

Protection of Participants

The researcher was careful to ensure the protection of participants throughout the entire research study. Standard CSULB IRB protocol was followed to ensure the protection of all of the participants in this study. Along with the standard CSULB IRB protocol, permission to conduct research in the specific districts where participants worked was received. Receiving IRB permission from their institutions further protected them in as much as their institutions felt that the benefits of the study far outweighed the minimal potential risks to their employees. None of the online survey data were collected with any identifying information. Further, at no time were IP addresses collected during the online data collection process. Participants were further protected in that they did not have to answer any question that made them feel uncomfortable. Names were not used during the focus group interview. Participants were given a number during the coding process for data analysis purposes. Like the online survey portion of the study, focus group participants were free to remain silent if any of the interview questions made them feel uncomfortable. Confidentiality of all participants was of the utmost importance to the researcher and no identifying information was used in any portion of this study. Lastly, all online survey data was placed on a password-protected computer and all paper surveys were kept in a locked file cabinet in the researcher's office as described in IRB.

Researcher Positionality

Chiseri-Strater (1996) stated, "All researchers are positioned whether they write about it explicitly, separately, or not at all" (p. 115). My research interests as well as the research methodology employed in this study are influenced by my positionality. My undergraduate work was in cell biology and my teaching career centered on biology, chemistry, and physics. I am extremely interested in science, science education, and the ways science is learned and taught. My background in science influences my overall views of science, science education, and of science educators in general.

Another factor driving my positionality is my current position as a school principal. My view of instruction has changed since I left the classroom. My role as an instructional leader has caused me to broaden my teaching ability. No longer do I teach students directly, but I work with people that are experts in their own content areas. My views on the importance of instructional leadership also create bias in my research.

Wahlstrom et al. (2010) state that, “leadership is second only to classroom instruction among school-related factors that affect student learning in school” (p. 3). Thus, strong instructional leadership is paramount to student learning.

These biases definitely influence my topic choice, my methodology, and may potentially have influenced my interpretations of the data collected. Stating these biases provides the reader with a lens with which to understand why important choices were made, and also how the data were analyzed. Also, by stating my biases, I have been able to check them throughout the research process. The critical review of my positionality also works to heighten trustworthiness.

Conclusion

This chapter provided an overview of the methodology that was used to explore the effects of STEM professional development, and more specifically, the factors that affect the self-efficacy of master teachers in teaching science. To provide an in-depth analysis of this, a rigorous mixed methods approach was utilized. The mixed method approach was complimentary in design and allowed the researcher to, “gain a fuller understanding of the research problem and/or to clarify a given research result” (Hess-Biber & Leavy, 2011, p. 281). This dissertation was guided by research questions aimed at exploring the factors that can lead to increased self-efficacy in teaching science for elementary school teachers.

Participants were recruited based on the specific criteria that they be master teachers working with student teachers, or that they had worked with student teachers in the previous 5 years. The treatment group consisted of master teachers that participated in a STEM-rich professional development series. The control group consisted of master teachers that had not participated in the STEM-rich professional development series. Precise descriptions of the research design, the participants, the data collection and analysis process, participant protections, and researcher positionality were also included in this chapter.

Given the problem statement posed in the first chapter of this dissertation and the general lack of science teaching that occurs in elementary schools, there is a clear need for research in this area. The methodology highlighted in this chapter was utilized to explore the factors that may increase self-efficacy in teaching science, and thus, the factors that may increase effective teaching practices in science at the elementary school level.

CHAPTER 4

STUDY FINDINGS

Introduction

The previous chapter outlined the methods used in both phases of this explanatory mixed methods study. The first phase included gathering and analyzing survey data. The second phase consisted of collecting and then analyzing focus group interview data to elaborate and add depth to the survey data. The explanatory mixed methods design was embedded in an overarching quasi-experimental design. The focus of this chapter will be to describe the findings in terms of the key research questions posed in Chapter 1 of this study. This study was guided by the following key questions:

1. Is there a difference in self-efficacy between the teachers that participated in the STEM professional development and teachers that did not participate in the STEM professional development?

2. To what extent do other factors influence elementary teacher's sense of self-efficacy in teaching science? Specifically, which, if any, of the following factors influence self-efficacy?

a. Teacher Pre-Service Knowledge Around Science.

b. Professional Development.

c. Interpersonal Supports.

d. Principal Instructional Leadership.

3. What aspects of the STEM-rich professional development most contributed to teachers' sense of self-efficacy in teaching science?

This chapter is structured in a way that focuses on each research question independently, while presenting quantitative and qualitative findings simultaneously. The first research question focuses on the self-reported level of self-efficacy in teaching science between the treatment group and the control group. The next section of this chapter focuses on Question 2, and, more specifically, on the four relevant factors found in the research to influence self-efficacy in teaching science. This question is based heavily on four factors that are prevalent in the current research on self-efficacy as related to teaching. Next, data relevant to research Question 3 is explained. Finally, analyses of the results are described and emergent themes are explored.

Data Analysis

Phase 1: The Survey

The two groups described in this study were master teachers that participated in the STEM-rich professional development (treatment, $n = 25$) and master teachers that did not participate in the STEM-rich professional development (control, $n = 25$). To test the effects of the STEM-rich professional development on teachers' sense of self-efficacy in teaching science, STEBI, which was developed by Enochs and Riggs (1990) was administered. Enochs and Riggs described STEBI as a "measurement tool that can lead to further understanding of teacher behavior, which in turn can facilitate the development of strategies which may assist in teacher preparation and teacher inservice designed to improve elementary science teaching" (p. 633). Further, Enochs and Riggs described the instrument as a tool to "help inservice teachers clarify their beliefs and to develop an organized conception of how these beliefs might be represented in behavior" (p. 634). Two scales are found within STEBI and are named the Personal Science Teaching Efficacy Belief (PTSE) scale and the Science Teaching Outcome Expectancy (STOE) scale. The PTSE portion of the instrument measures the level of belief that elementary school teachers have that they can teach science. The STOE portion of the instrument measures the effect the teachers feel they will have on their students. The STOE and PTSE portions of the STEBI were reported independently for all statistical analyses.

Phase 2: The Focus Group Interviews

The interviews for this study were conducted using a semi-structured, open-ended focus group interview method. This method led to a dynamic interaction between participants and encouraged participants to not only respond to the questions, but also to respond to each other. A focus group interview was held for both the treatment group of master teachers (*n* = 8) and the control group of master teachers (*n* = 7). The interview consisted of 10 open-ended questions focused on the three guiding questions in this study as well as other key factors found in the literature. All of the participants agreed to have the interview audio recorded. After completion of the audio recordings, they were transcribed and reviewed for emergent themes. During the coding process, the key recurring themes that emerged were noted and key quotes were underscored.

Treatment group focus group interview. The treatment group consisted of 25 master teachers serving in an urban school district. Of the 25 master teachers, eight agreed to participate in a focus group interview conducted after 2 years of STEM PD. Demographic and background details of the interviewees (*n* = 8) that participated in the treatment group focus group interview are outlined in Table 8.

Control group focus group interview. The control group consisted of 25 master teachers serving in an urban school district similar to the participating district. Of the 25 master teachers, seven agreed to participate in a focus group interview. Demographic and background details of the interviewees (*n* = 7) that participated in the treatment group focus group interview are outline in Table 9.

TABLE 8. Demographic Table of Participants in Treatment Group Focus Group Interview

Participant Number	Current Grade Taught	Gender	Total Years Teaching
1	5	Female	15
2	$3^{rd}/4^{th}$	Male	13
3	5	Female	20
4	TK	Female	18
5	Pre-K	Female	20
6	5	Male	25
7	$4^{th}/5^{th}$	Male	13
8	4	Female	32

TABLE 9. Demographic Table of Participants in Control Group Focus Group Interview

Participant Number	Current Grade Taught	Gender	Total Years Teaching
1	K	Female	20
2	3^{rd}	Female	26
3	K	Female	19
4	TK	Female	20
5	$4^{th}/5^{th}$	Female	13
6	5	Female	16
7	5	Male	26

Student teacher coordinator interviews. Interviews of two student teacher coordinators from the university were conducted to gain a well-rounded picture of the effects of the STEM-rich professional development on master teachers' sense of self-efficacy in teaching science. While the student teacher coordinators work primarily with the student teachers in the teaching credentialing program, they work as a liaison between the student teacher and their master teacher. They also meet with the master teachers on a regular basis to discuss the progress of the student teachers and to recommend ways to support their student teachers. These interviews added another dimension to the study by gaining insight into the master teachers, both as participants in the STEM-rich professional development and as supervisors of student teachers. Unlike the focus group interviews, the student teacher coordinator interviews were held individually. The interviews for this portion of the study consisted of 10 semi-structured, open-ended questions (Appendix H). Both of the interviewees agreed to have the interview audio recorded. Emergent themes were discovered after multiple coding cycles of the transcribed interviews. Both student teacher coordinators have been working with teachers for a number of years; however, this was their first experience with science specific professional development aimed at providing master teachers with additional tools to increase self-efficacy in teaching science.

Analyses of the interview transcripts as well as survey results are presented concurrently to provide triangulation of the data. This was also done in an effort to give richer descriptions of the data through qualitative and quantitative methodologies.

Research Question 1

Is there a difference in self-efficacy between the teachers that participated in the STEM professional development and teachers that did not participate in the STEM professional development?

To test this question, an independent samples *t*-test was performed comparing survey data between the two groups. The null hypothesis was that there would be no difference in the self-reported level of self-efficacy in teaching science between the treatment group and the control group. The alternate hypothesis was that there would be a significant difference in the self-reported self-efficacy in teaching science between the two groups. The mean and standard deviations were compared and significance was determined by a *p*-value less than .05. Tables 10 and 11 illustrate the findings of an independent samples *t*-test for the STOE portion and the PTSE portion of the STEBI respectively.

TABLE 10. Independent Samples *t*-Test of Mean of Difference of Self-Reported Sense of Self-Efficacy in Teaching Science for STOE Portion of STEBI

Group Statistics					
	STEMPD	*N*	Mean	Std. Deviation	Std. Error Mean
Self Efficacy	Treatment Group	25	42.8400	5.85719	1.17144
	Control Group	25	31.1600	3.86954	.77391

Those who participated in the STEM-rich professional development (*M* = 42.84, *SD* = 5.86) had significantly higher self-efficacy scores on the STOE portion of the STEBI than those who did not participate in the STEM-rich professional development (*M* = 31.16, *SD* = 3.87), $t(48) = 8.32$, $p < .05$, $d = 2.35$. Effect Size was calculated using J. Cohen's (1988) method, where:

$$d = t\sqrt{\frac{N_1 + N_2}{N_1 * N_2}} \text{ Thus, } d = 98.319\sqrt{\frac{25+25}{25*25}} \qquad d = 2.35$$

Based on the work of J. Cohen (1988), the effect size of 2.35 is very large and indicates that the treatment group had self-efficacy scores that were 2.35 standard deviations higher than the self-efficacy scores of the control group. Table 11 illustrates the findings of an independent samples *t*-test for the PTSE portion of the STEBI.

TABLE 11. Independent Samples *t*-Test of Mean of Difference of Self-Reported Sense of Self-Efficacy in Teaching Science for PTSE Portion of STEBI

Group Statistics					
	STEMPD	*N*	Mean	Std. Deviation	Std. Error Mean
Self Efficacy	Treatment Group	25	53.4800	8.87468	1.77494
	Control Group	25	31.4800	7.11875	1.42375

Those who participated in the STEM-rich professional development ($M = 53.48$, $SD = 8.87$) had significantly higher self-efficacy scores on the PTSE portion of the STEBI than those who did not participate in the STEM-rich professional development ($M = 31.48$, $SD = 7.12$), $t(48) = 9.67$, $p < .05$, $d = 2.73$. Effect Size was calculated using Cohen's (1988) method, where:

$$d = t\sqrt{\frac{N_1 + N_2}{N_1 * N_2}} \text{ Thus, } d = 9.669\sqrt{\frac{25+25}{25*25}} \qquad d = 2.73$$

Based on the work of J. Cohen (1988), the effect size of 2.73 is very large and indicates that the treatment group has self-efficacy scores that are 2.73 standard deviations higher than the self-efficacy scores of the control group.

To further inspect the results, interview data were gathered and common themes emerged. All of the major themes that were found in this study were linked specifically to Bandura's (1977) theory of self-efficacy, and more specifically to social cognitive theory (1986). Bandura (1997) postulated that self-efficacy is built on four domains: performance outcomes, physiological feedback, verbal persuasion, and vicarious experiences. Of the four domains, performance outcomes and verbal persuasions stand out as common themes discussed by all groups in this study.

Each of the master teachers that participated in the STEM-rich professional development also had extensive experience in the field of teaching. Their teaching experience undoubtedly played a factor in their responses. An increased sense of self-efficacy was evidenced while coding with a focus on Bandura's (1977) social cognitive theory. Primarily, teachers felt an increased sense of self-efficacy based on performance outcomes and verbal persuasions. Interestingly, the verbal persuasions were centered on elementary student comments and not those of colleagues or administrators.

Performance Outcomes

Bandura (1997) stated that performance outcomes might be the most influential source of self-efficacy because they provide the most accurate evidence of success or failure for a given task. This theme seemed to be tied with interpersonal supports. Teachers that worked together, learning from a more experienced science teacher, tried science more often, and were successful. This success led to an increase in self-efficacy in teaching science. One teacher stated,

> At least one (teacher) in particular was really doing good work too with science before that. The others were not doing any science that I could see whatsoever. So, for the two who were doing science . . . they just got much better and more professional and deeper with their science with higher level thinking, with strategies with the activities because they already knew the science giving them the activities and having them participate in activities helped them take it from the theoretical to the hands on real.

Verbal Persuasions

Bandura (1977) suggested that words of encouragement could persuade the receiver, even in the absence of skill, that they can perform a given task if they try hard enough. One participant noted,

> I have kids coming to me at the end of the year and they want to be scientist. I mean I've never heard that before but as soon as you start it, you'll hear more like I want to be a scientist.

This encouraged the group. Another teacher noted, "I think some of those kids that you don't normally reach when you're doing other things, you're able to get to them. I mean they're excited about it." Comments like these led participants to share that they were more likely to teach science when students tell them, or show them, how engaged they get during science lessons. Other instances of verbal persuasions as an indicator of increased self-efficacy came in the form of communication with colleagues. One teacher stated,

> So, they began to have conversations that I actually witnessed between grade levels that were not forced or formal about science and sharing materials and books and just to change the dialogue from, what are we going to test on to, how can we make this curriculum work.

Other forms of verbal persuasions came in the response students had to increased science instruction in the classroom. When teachers were asked what they liked most about teaching science, they expressed it was the way students reacted. One teacher said, "I think some of those kids that you don't normally reach when you're doing other things, you're able to get to them. I mean, they're excited about it." Some of the words used to describe students participating in science lessons were: "excited"; "interested," "happy"; "engaged"; and "creative." They also described the phenomenon of increased interest outside of the classroom. One teacher stated, "they find something that's interesting to them and they want to get books from the library about it or they go home and ask their parents things about it and to look on the Internet."

Summary: Research Question 1

Teachers that participated in the STEM-rich professional development had a significantly higher sense of self-efficacy in teaching science than those that did not participate ($p = 0.00$, $p < .05$). This was supported by what teachers in the experimental group said about the effects the STEM-rich professional development had on their science teaching practices. Also, this was confirmed on both the PTSE and STOE portions of the STEBI survey. Teachers' sense of self-efficacy in teaching science was especially affected in the areas of performance outcomes and verbal persuasions. Performance outcomes were a major theme across the treatment group in terms of their willingness to try what they had learned during the STEM-rich professional development. Once they put into practice their newfound skills, they saw positive reactions from students and their self-efficacy increased. Further, verbal persuasion, mainly from students, encouraged the treatment group to continue teaching science.

Research Question 2

To what extent do other factors influence elementary teacher's sense of self-efficacy in teaching science? Specifically, which, if any, of the following factors influence self-efficacy?

a. Teacher Pre-Service Knowledge Around Science.

b. Professional Development.

c. Interpersonal Supports.

d. Principal Instructional Leadership.

The major themes listed in Question 2 are the most relevant themes based on current literature. Data presented on this question is primarily qualitative in nature. Teachers in both the treatment group and the control group shared sentiments regarding the four major themes. Of the four themes, major concerns arose around teacher pre-service knowledge of science, professional development, and principal instructional leadership. There are mainly negative examples of how these three categories affect self-efficacy in teaching science. The only positive examples leading to increased self-efficacy came from participation in the STEM-rich professional development and from interpersonal supports.

Teacher Pre-Service Knowledge Around Science

Teachers from both groups were master teachers with extensive experience in the teaching field. Even with all of the experience that they had, concerns about knowledge gained from pre-service programs were a major problem. One teacher summed up the sentiments of both groups. She stated, "I remember taking a science methods class and really enjoying it and being interested, but I don't think that I was particularly prepared to teach science." When asked why some teachers are more self-efficacious in teaching science than others, multiple teachers responded, "(because of) their content knowledge." All of the teachers were aware of their own lack of preparation to teach science. Another major factor shared was, "their interest (in science)." Teachers agreed that they received extensive training through methods and content courses on reading, writing, and mathematics. One interviewee stated, "Some of the teachers don't like to teach science because when they read that textbook or they read the teachers' guide they don't really understand what they're talking about." This lack of content knowledge was a major source of lowered self-efficacy in teaching science. Further, the teachers in the treatment group stated that though their experiences in their pre-service programs was lacking, it was the lack of professional development around science that really affected how they felt about teaching science. One participant stated,

> As beginning teachers, I don't know that you're really truly prepared to teach a whole lot of anything until you actually jump in and start doing some of that teaching. Especially coming to this professional development it gives me a window of like more vision, maybe more tools.

This suggested that science-specific professional development might be enough to overcome the lack of teacher preparation specifically in science. It also suggests that teachers gain more self-efficacy once they are in a classroom and are teaching science successfully, which is described by Bandura (1977) as "performance outcomes."

<u>Professional Development</u>

The importance of professional development was another recurring theme that emerged in the data. Teachers that participated in the STEM-rich professional development stated that they feel more prepared to teach science. One participant stated,

> You really can't teach science if you've just been trained with a textbook. Because when you teach the kids, you're going to do the same thing, you're going to teach with a textbook, you're just going to lecture to them, right? So, I feel like now I have lots of tools, I have bases that I can go to. I feel like, you know, I have these sources, especially coming to this professional development.

All of the participants in the treatment focus group session agreed by nodding or stating "yes" when that statement was made. Further evidence of the success of the professional development came from the two student teacher coordinators. When asked what aspects of the professional development were successful in increasing self-efficacy for the master teachers in the treatment group, one coordinator stated, "Well, I think you have to have things that the teachers can actually see, that they can take from this and carry into the classroom." He continued by stating,

> And then have something you can carry away. You need both. You can't just have activity but you just can't have activity free of any kind of content that the kids are going to learn from it. And I think that's what you need is strong content with doable types of activities that teachers can visualize using in their own classrooms.

The second student teacher coordinator echoed this sentiment. She stated, "So I think keeping it focused on the curriculum that they can use in the classroom without a lot of expensive equipment, just modeling how to teach it." Overwhelmingly, the student teacher coordinators and the master teachers in the treatment group felt that the STEM-rich professional development aided participants to increase their self-efficacy in teaching science.

Master teachers in the control group shared a desire to participate in a science specific professional development. They shared that there was an obvious lack of professional development centered on science. When asked what would help increase their sense of self-efficacy in teaching science, one teacher stated, "That's what makes us better [professional development], I mean in understanding science better." Universally, the master teachers in the control group stated that while they desired professional development around science, they had never had the opportunity to attend any type of training or workshop specific to teaching science. When asked if any of them had attended a science specific professional development, they all responded negatively. All seven teachers in the control group stated, "we haven't received any science training."

Despite the lack of training in science, both in the form of pre-service training and professional development, teachers in the control group stated that they were doing the best that they could with what they had. All of the participants agreed with the account of one teacher,

> We did the scientific method across K through fifth, and we did it as a shared reading, going over the scientific method steps and then doing two experiments and presenting. But using the kits that came with the science teacher's edition but not specific training. I mean, we try to do the best with what we have and try to collaborate.

Teachers in both the treatment and control groups described the benefits of attending professional development to improve their teaching practice. Principal instructional leadership was almost as important to effects on their overall self-efficacy as professional development. Teachers in both groups described that an unsupportive principal led to a decreased sense of self-efficacy in teaching science. The consistency of their comments about how principals affect their overall self-efficacy led to another major theme: principal instructional leadership.

Principal Instructional Leadership

Wahlstrom et al. (2010) state, "leadership is second only to classroom instruction among school-related factors that affect student learning in school" (p. 3). Further, research suggests that poor instructional leadership is a major cause of low self-efficacy (Edmonds, 1979). Teachers in both the treatment group and the control group agreed that the support of their instructional leader was a major factor in how science was taught. Teachers agreed with the statement of one master teacher regarding principal support: "But the administrators, all of them, I have had three of them already and they haven't supported." Further, the student teacher coordinators made similar observations about the general lack of support for science professional development. In their position as student teacher coordinator, they work directly with principals and they advocate for their master teachers and student teachers to provide the best learning environment possible to foster good teaching practices. That said, they both commented that from their point of view, "it's not just that they [the teachers] weren't prepared but it hasn't been encouraged."

One of the master teachers had an ambivalent view of the support provided by her principal. She stated, "But I wouldn't say that there is any administrator support in particular. There's no obstruction to it [teaching science]. It's not like, well, let me pay you a stipend or something for all of this extra work you're doing." While there was a general sense that principal support was lacking, one teacher noted that their principal was excited to see science instruction in the classroom. She stated, "They [the principal] would come up and make observations and they would give nice comments. In that way they supported what we were doing but not anything big in the way of purchasing a science lab or anything." One of the student teacher coordinators made an interesting observation regarding the Family STEM Night. He stated, "The principal was filming it on his IPad and people were extremely excited about the idea of the kids being able to do these experiences and went with the kids and monitored them."

After a thorough review of the data, two sub themes emerged with regards to principal instructional leadership support: science supplies and competing demands. All of the teachers agreed that there was a general lack of science supplies. One participant summed up the experiences of all of the teachers in the group by simply stating, "I don't have the materials I need for a lesson." They stated that their principals were not likely to support them by spending money on science supplies because of the costs associated with the supplies. One teacher made an interesting observation. She stated,

> There were no materials at the school that were readily available, you know, as far as classroom material to do any kind of interactive hands-on activities with my class. So it was a while before what I wanted to do and what I was able to do was kind of put together enough for me to actually partake in teaching science in earnest anyway.

Other comments suggest that teachers are often left to spend personal resources to obtain the materials necessary to teach science properly. One teacher commented, "I have a lot of materials, but I've bought them with my own money. That's where I get my materials." Directly following that comment, the same teacher noted, "it's hard to keep spending my money when I have a limited amount of money myself." When asked about possible reasons regarding the lack of spending money on science supplies, one teacher stated, "But certainly science was more of an afterthought at that particular school." Teachers overwhelmingly cited competing curricular demands as a barrier to increased spending on science supplies. Master teachers in the control group stated,

> You know because we've been told do this, do this, do this, but it was reminding you of, oh yeah, remember we used to do this [teach science] and it has the value if you can fit it in. The question is where and when you fit it in?

Specifically, a teacher in the treatment group stated, "I mean there's all these competing demands." Overall, teachers shared their desire to teach science, but at the same time commented on the difficulty of fitting it in. One such comment caused the entire group to respond in agreement; "I don't think we have paid that much of attention to science as we do to math and language arts. Everything revolves around math and language arts." This may be due specifically to the demands of NCLB, which put an overwhelming emphasis on math and language arts scores. NCLB narrowed the focus of education by increasing accountability standards that focused mainly on reading, writing, and mathematics (Duncan, 2010). Thus, when asked when they taught science, teachers in both the treatment and control group agreed, "at the end of the year, after testing." One teacher shared her experience with the inception of NCLB:

> Then, a couple of years later, there was a push for reading, writing, and math. So like they cleared out the classroom. The block [of time to teach science] was gone. No more block. So at that time because the student needed to be reading at a certain grade level so it was pushed for reading and writing instead of science stuff.

In general, teachers commented on the lack of principal support around science. They cited specific reasons, such as the cost of science supplies and the barriers that arose with competing demands. Principals were less likely to purchase science supplies because science was not tested in all grade levels according to NCLB. This caused science to take a back seat to other core subject areas such as reading, writing, and mathematics.

Interpersonal Supports

Like participation in the STEM-rich professional development, interpersonal supports seemed to be a positive factor leading to an increased sense of self-efficacy in teaching science. Some teachers stated that their only sense of self-efficacy came from collaborating with colleagues that had prior knowledge in teaching science. One teacher stated, "I mean we haven't attended any training other than us collaborating." Subsequently, the same participant stated, "I think the reason why we do science and that we're here is because we have somebody else that we do it with, and we can plan." This comment led other participants to share their experiences with collaboration around science instruction. On another occasion, the group suggested that collaboration with colleagues helped them teach science, which led to increased self-efficacy. One teacher stated,

> I know my science lessons go much better when the two of us are bouncing ideas off of each other and coming up with a unit together rather than sitting and trying to pull it off, because it is a lot of work.

Most of the other participants agreed when this statement was made. Collaborating with a teacher that already had high self-efficacy in teaching science encouraged the other teachers to try it out. Once they did, their level of thinking and the strategies that they were using improved also. Once these teachers experienced success with science, their sense of self-efficacy increased.

The student teacher coordinators both noted that the master teachers that participated in the STEM-rich professional development seemed to increase the amount of time they spent planning science lessons. One coordinator noted,

> So, they began to have conversations that I actually witnessed between grade levels that were not forced or formal about science and sharing materials and books and just to change the dialogue from, what are we going to test on to, how can we make this curriculum work.

The second student teacher coordinator summed it up by stating, "When they came together as a group they came together as professionals." This work as professionals helped to increase their collective sense of self-efficacy in teaching science. Master teachers in both the treatment group and the control group agreed that collaboration had a positive effect on their sense of self-efficacy in teaching science.

Summary: Research Question 2

All four of the emergent themes in the current literature surfaced as a result of this study. Of the themes found in the literature, major concerns arose around teacher pre-service knowledge of science, professional development, and principal instructional leadership. These three factors seemed to negatively impact teachers' sense of self-efficacy in teaching science. All participants in the study noted the general lack of these three factors. Had these factors been present, the general consensus was that they would have positively impacted teachers' sense of self-efficacy in teaching science. Two factors emerged as positive factors leading to an increased sense of self-efficacy in teaching science: Participation in the STEM-rich professional development and interpersonal supports. Master teachers in the treatment group shared that their experience in the STEM-rich professional development was unlike any other experience in their teaching careers. They cited specific evidence showing that their participation in the STEM-rich professional development led to an increase in their collective self-efficacy in teaching science. Further, teachers in both the treatment and control groups noted that interpersonal supports led to increased self-efficacy in teaching science.

Research Question 3

What aspects of the STEM-rich professional development most contributed to teachers' sense of self-efficacy in teaching science?

Both of the student teacher coordinators noted that the STEM-rich professional development helped master teachers with self-efficacy in teaching science. A common theme noted by both student teacher coordinators was the power of the professional development being provided by a third party. This allowed the master teachers to participate without feeling that someone from the district was the "expert" and they were the "unlearned." One coordinator noted, "[the] professional development kind of leveled the playing field so no one was the expert." Later, the interviewee stated, "viewing the professional development I did see the master teachers and the student teachers as equals, as learners, because of the outside third party providers of the professional development."

The second coordinator noted similarly,

> I think it had a really high impact because the way it was presented was in a way where they would connect these activities that were very interesting and hands on, the kind of theoretical principles. So, I think that they really made connections very well when it was that kind of inquiry based teaching.

Further, every teacher was participating in a professional development centered on science for the first time in his or her career. The STEM-rich professional development was an aligned, intentional, purposeful, ongoing, and differentiated professional development. The professional development was aligned with NGSS and focused on both content and pedagogy. A major strength of the professional development was the focus on content, as many elementary school teachers lack science content knowledge. The focus on content by experts in science led to an increase in self-efficacy in teaching science. The professional development also had imbedded projects to focus on science teaching pedagogy. One such project was the Family STEM Night.

The implementation of a Family STEM Night was a novel idea. The event was co-created by the master teachers and their student teachers. The event encouraged the participants to display what they had learned to the students, and the community at large.

Family STEM Night

The master teachers, in concert with their student teachers, were charged with hosting a Family STEM Night to showcase what they had learned during the STEM-rich professional development. The Family STEM Night was hosted by the master teachers, run by the student teachers, and included the PTA, administration, and other staff members. Teachers set up science experiments that they had learned from the STEM-rich professional development, or experiments that they had created on their own. This is significant, because prior to the STEM-rich professional development, none of the participants had hosted an event of this nature. Their willingness to share their new knowledge was clear evidence that there was an increase in teachers' sense of self-efficacy in teaching science.

Both student teacher coordinators noted the significance of the Family STEM Night on teachers' sense of self-efficacy. One coordinator stated:

> There's not much to do with your family in those neighborhoods, there really isn't. You can go to the CVS and walk around or walk by the transmission shop. I think there may be one park over by [the school] but it's really small with a gazebo in it but there are no big parks. So, a community event was unique and I think the response was huge for the families there.

The second interviewee stated, "So, their efficacy in working with parents and working with science and putting on an event for the student teachers was huge." The Family STEM Night was cited as one source of evidence that the STEM-rich professional development positively impacted teachers' sense of self-efficacy in teaching science. Further evidence of effects of STEM-rich professional development was identified by both of the student teacher coordinators.

Teachers' sense of self-efficacy in teaching science was positively impacted as a result of their participation in the STEM-rich professional development in many ways. Both student teacher coordinators shared explicit observations of increased self-efficacy as a result of positive performance outcomes. They shared that teachers were consistently teaching science, and those that shied away from science increased the amount and quality of science instruction. One of the student teacher coordinators passionately described her observations:

> There were a couple of teachers who had been teaching science or engineering on a fairly consistent basis. But even those teachers went deeper into the whys and they were doing . . . at least one in particular was really doing good work too with science before that. The others were not doing any science that I could see whatsoever. So, for the two who were doing science . . . they just got much better and more professional and deeper with their science with higher level thinking, with strategies with the activities because they already knew the science giving them the activities and having them participate in activities helped them take it from the theoretical to the hands on real. The ones who hadn't taught science, because they didn't feel they knew the content, the materials were a pain to get together, they were expensive and it's messy and it takes a lot of time and they began to see the benefit of the science for all of their students.

According to Bandura's (1977) social cognitive theory, the positive performance outcomes experienced by these teachers would lead to increased self-efficacy. As self-efficacy increases, behaviors are affected (more and better science instruction) and students are positively impacted as a result.

The positive effects of the STEM-rich professional development are also evidenced by the results of the survey data. A paired samples *t*-test was run to compare the self-reported level of self-efficacy in teaching science of the treatment group. The STEBI was administered to the treatment group on the first day of the professional development (pre-survey) and again on the last day of the professional development (post-survey). A paired-samples *t*-test was run to see if there was an increase in the self-reported level of self-efficacy in teaching science at the conclusion of the STEM-rich PD series. The null hypothesis was that there would be no difference in the self-reported level of self-efficacy in teaching science between the pre-survey and the post-survey. The alternate hypothesis was that there would be a significant difference in the self-reported self-efficacy in teaching science between the pre-survey and the post-survey.

The mean and standard deviations were compared and significance was determined by a *p*-value less than .05.

Tables 12 and 13 illustrate the findings of the paired-samples *t*-test for the STOE portion and the PTSE portion of the STEBI respectively.

TABLE 12. Paired Samples *t*-Test of Mean of Difference of Self-Reported Sense of Self-Efficacy in Teaching Science for STOE Portion of STEBI

Paired Samples Statistics					
		Mean	*N*	Std. Deviation	Std. Error Mean
Pair 1	PostTest	45.3043	23	6.44864	1.34463
	PreTest	44.5217	23	3.71569	.77477

There was not a statistically significant difference between participants' sense of self-efficacy on the STOE portion of the STEBI between the pre-test (M = 44.52, SD = 3.72) and the post-survey (M = 45.30, SD = 0.6.45), $t(22) = 0.453$, $p > .05$, $d = 0.095$. Effect Size was calculated using J. Cohen's (1988) method, where:

$$d = \frac{\mu_\chi}{\sigma_\chi} = \frac{0.7826}{8.27898} = 0.95$$

Based on the work of J. Cohen (1988), the effect size of 0.95 is extremely small and indicates that on the STOE portion of the STEBI, the post-survey self-efficacy scores were 0.95 standard deviations higher than the pre-test self-efficacy scores of the treatment group. This may be due to teachers' general sense of self-efficacy in teaching. The STOE portion of the instrument measures the effect the teachers feel they will have on their students. Teachers generally believe that they will be able to positively impact student learning, even in the absence of evidence. Table 13 illustrates the findings of a paired-samples *t*-test for the PTSE portion of the STEBI.

TABLE 13. Paired Samples *t*-Test of Mean of Difference of Self-Reported Sense of Self-Efficacy in Teaching Science for PTSE Portion of STEBI

Paired Samples Statistics					
		Mean	*N*	Std. Deviation	Std. Error Mean
Pair 1	PostTest	53.6522	23	9.24716	1.92817
	PreTest	36.2609	23	3.60829	.75238

There was a statistically significant difference between participants' sense of self-efficacy on the PTSE portion of the STEBI between the pre-survey (M = 36.26, SD = 3.61) and the post-survey (M = 53.65, SD = 9.25), $t(22) = 7.94$, $p < .05$, $d = 1.66$. Effect Size was calculated using J. Cohen's (1988) method, where:

$$d = \frac{\mu_\chi}{\sigma_\chi} = \frac{17.391}{10.504} = 1.66$$

Based on the work of J. Cohen (1988), the effect size of 1.66 is very large and indicates that on the PTSE portion of the STEBI, the post-survey self-efficacy scores were 1.66 standard deviations higher than the pre-test self-efficacy scores of the treatment group. The PTSE portion of the instrument measures the level of belief that elementary school teachers have that they can teach science. Thus, the STEM-rich professional development had a significant effect on teachers' sense of self-efficacy in teaching science.

<u>Summary: Research Question 3</u>

Analysis of the data gathered to answer research Question 3 shows that the STEM-rich professional development positively affected teachers' sense of self-efficacy in teaching science. More specifically, their belief that they can teach science was positively impacted. Some of the most effective aspects of the professional development included the delivery method, the imbedded Family STEM Night, and the fact that there was professional development focused specifically on science. For every teacher, this was the first time they had participated in a professional development centered on science. The STEM-rich professional development was aligned, intentional, purposeful, ongoing, and differentiated.

Summary of Study Findings

A thoughtful analysis of the data led to several key findings. Central to the findings was the fact that the STEM-rich professional development positively and significantly improved the treatment group's general sense of self-efficacy in teaching science. The treatment group's increase in self-efficacy in teaching science was especially affected in the areas of performance outcomes and verbal persuasions. Further, all four literature-based factors played a role teachers' sense of self-efficacy in teaching science. Universal concerns arose around the lack of teacher pre-service knowledge of science, the lack of science-centered professional development, and the lack of principal instructional leadership, specifically in science. Participation in the STEM-rich professional development and interpersonal supports emerged as common positive themes leading to an increased sense of self-efficacy in teaching science. Lastly, teachers' belief that they can teach science was most significantly impacted through participation in the STEM-rich professional development. The most effective aspects included the delivery method, the imbedded Family STEM Night, and the aligned, intentional, purposeful, ongoing, and differentiated nature of the professional development.

CHAPTER 5

CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

Introduction

The purpose of this research was to study the effects of STEM-rich professional development on teachers' sense of self-efficacy in teaching science. One of the major influences on elementary school teachers' comfort level with and ability to teach science is self-efficacy (Akerson & McDuffie, 2002). Self-efficacy is defined as, "Peoples' judgment on their capabilities to organize and execute courses of action required to attain designated types of performances" (Bandura, 1986, p. 391). This is significant because research states that there is a correlation between self-efficacy and outcome expectancy (Riggs & Enochs, 2006). Thus, a highly self-efficacious teacher will be more likely to have positive effects on student learning (Arambula-Greenfield & Feldman, 1997). However, research also states that there is a deficiency of adequately trained teachers to prepare students to be successful in STEM fields (DoD, 2009). This lack of STEM-trained teachers has created a climate where the United States continues to lag far behind other countries in developing scientific knowledge and literacy (NSB, 2010). As a result, it is projected that, "The nation will become less competitive in the global economy" (Carnevale, Smith, & Melton, 2011). Further, the shortage has directly impacted teaching and learning centered around science in general, which has created a bottleneck effect on the pipeline of STEM-qualified educators that can prepare students to enter the

STEM workforce. This research studied the effects of a STEM-rich, clinical model, of professional development as one possible answer to the continuing STEM crisis.

This study was guided by the following key questions:

1. Is there a difference in self-efficacy between the teachers that participated in the STEM professional development and teachers that did not participate in the STEM professional development?

2. To what extent do other factors influence elementary teacher's sense of self-efficacy in teaching science? Specifically, which, if any, of the following factors influence self-efficacy?

a. Teacher Pre-Service Knowledge Around Science.

b. Professional Development.

c. Interpersonal Supports.

d. Principal Instructional Leadership.

3. What aspects of the STEM-rich professional development most contributed to teachers' sense of self-efficacy in teaching science?

Summary of Research

This study utilized an explanatory mixed methods approach consisting of first, gathering and analyzing quantitative data, and then, collecting and analyzing qualitative data to elaborate and add depth to the quantitative data. The study was conducted in two phases, allowing the researcher to gather both quantitative and qualitative data. Quantitative data were gathered via the administration of a 25-question survey. The survey instrument utilized was STEBI, which was developed by Enochs and Riggs (1990). The instrument consists of two categories of questions, PTSE and STOE. The

PTSE portion of the instrument measures the level of belief that elementary school teachers have that they can teach science. The STOE portion of the instrument measures the effect the teachers feel they will have on their students.

The qualitative data were gathered using semi-structured, open-ended focus group and individual interviews. The focus group interview questions focused on effects of the STEM-rich professional development and on other key factors found in the literature regarding elementary teachers' self-efficacy in teaching science. The university student teacher coordinator interviews were conducted individually. The questions focused on the perceptions that the student teacher coordinators had with respect to master teachers' self-efficacy. Again, the questions were derived from the literature and they aimed at strengthening the data so as to help answer the two research questions.

Major Research Findings

The major research findings indicate that the STEM-rich professional development was successful in significantly increasing teachers' sense of self-efficacy in teaching science. The most significant difference was found between the treatment group and the control group. For the STOE portion of the STEBI the treatment group had self-efficacy scores that were 2.35 standard deviations higher than the self-efficacy scores of the control group. Similarly, for the PTSE portion of the STEBI, the treatment group had self-efficacy scores that were 2.73 standard deviations higher than the self-efficacy scores of the control group. Further, the interview data corroborates the quantitative data. The focus groups and the university student teacher coordinators reported both positive and negative examples of self-efficacy. The positive examples were those described by the participants to be present and positively impacting their sense of self-efficacy in teaching science. Positive examples of self-efficacy included participation in the STEM-rich professional development, performance outcomes, verbal persuasions, and interpersonal supports. The negative examples of self-efficacy were those that participants described as missing and/or desired to improve their self-efficacy in teaching science. The negative examples of self-efficacy included teacher pre-service knowledge around science, professional development, and principal instructional leadership.

Positive Examples of Self-Efficacy

The most significant increase in self-efficacy described by the data was found amongst the teachers that participated in the STEM-rich professional development. Treatment group participants experienced a significant increase in their self-reported sense of self-efficacy as a result of their participation in the STEM-rich professional development. Correspondence between survey data and interview data further strengthen this finding. Teachers in the treatment group also reported that their self-efficacy was positively impacted as a result of what Bandura (1977) described as performance outcomes and verbal persuasions. Teachers worked together and implemented what they had learned in the professional development. Teachers' sense of self-efficacy in teaching science was positively impacted after they experienced success with science lessons. They also noted an increase in student engagement during science, which added to the increase in self-efficacy. Likewise, teachers in both the treatment group and the control group stated that working with colleagues on lesson design and implementation positively impacted their sense of self-efficacy in teaching science. Most interesting of all may be the effects of verbal persuasions on teachers' sense of self-efficacy. Bandura (1977) suggested that words of encouragement could persuade the receiver, even in the absence of skill, that they can perform a given task if they try hard enough. Research suggests that self-efficacy is affected by verbal persuasions from colleagues or administrators; however, the data herein describes a different phenomenon. The findings suggest that verbal persuasions came primarily in the form of student feedback. Participants shared that they are more likely to teach science when students tell them, or show them, how engaged they get during science lessons.

<u>Negative Examples of Self-Efficacy</u>

While positive examples of self-efficacy were those experienced by participants, negative examples of self-efficacy were those that were most talked about. Master teachers in both the treatment group and the control group expressed that a lack of pre-service and in-service training around science content and pedagogy negatively impacted their sense of self-efficacy in teaching science. All of the participants shared concerns with the lack of pre-service training in science. Likewise, both groups expressed the lack of professional development opportunities around science. None of the participants in either group had attended professional development specifically on science instruction prior to the STEM-rich professional development described in this study. The control group teachers shared their desire to attend science specific professional development. They stated that they felt their self-efficacy in teaching science would increase if they had the opportunity to attend science specific professional development. Participants made a connection between the lack of science professional development and the general lack of support from instructional leaders in the area science. Participants described competing demands as the major cause for this lack of support.

Competing demands were cited as the cause of lack of support from instructional leaders. All participants have experienced professional development in the areas of reading, writing, and mathematics. These seem to be the major areas of focus for most instructional leaders as these are the major subjects found on state assessments. While all participants agreed that these subjects are imperative to student success, they noted that the importance placed on these content areas by instructional leaders left little to no room for science instruction. Further, science supplies were found to be a major concern as a result of competing demands. Participants in both groups stated that there was a general lack of the science supplies necessary to adequately teach science. This was due in large part to the focus on other content areas. With the emphasis on reading, writing, and math, instructional leaders were less likely to spend funds on science supplies. This general lack of support necessitated that teachers spend their own money on science supplies, furthering the likelihood that science would not be taught in elementary school. Multiple teachers noted a desire to teach science, but similarly noted that they were not able or willing to purchase the materials necessary to adequately teach science in their classrooms.

Implications for Policy

Specific science policy is set by a multitude of competing organizations. At the highest level, a branch of the National Science Foundation (NSF), the National Science and Technology Council (NSTC), called for by the America Competes Reauthorization Act of 2010, sets national policy for STEM education. Of significance is the fact that funding for national science policy is tied directly to DoD. This began in 1958 when President Eisenhower realized that the United States needed to, "increase its support of basic research and expand its programs for science-teacher training and other efforts contributing to the quality of science education" (Killian, 1959, p. 129). From there, the California State Board of Education (CSBE) sets forth the specific standards that must be taught throughout the state. With the inception of CCSS, CSBE adopted the Next Generation Science Standards for California Public Schools (CA NGSS) in 2013. NGSS outlines the science standards for science education in Kindergarten through the 12th grade. From there, each school district interprets NGSS to implement a verified science program to ensure students' needs are met. That said, many of the policies set forth by the federal government get "watered down" by the time they reach the classroom.

Policy on the importance of science education at all levels of education is present (Duncan, 2010), however, implementation of these policies is not common (Southerland, 2013). For many elementary teachers, teaching science is not a priority for many reasons. First, competing curricular demands stifle science instruction as there is a focus on reading, writing, and mathematics. Further, for the most part, teachers are ill prepared to teach complex science concepts (Akerson & McDuffie, 2002). One of the major factors that could remedy this deficiency in teachers' ability to teach science is professional development. As previously stated, competing demands leave little room for science-specific professional development. Generally, inservice teachers do not receive meaningful professional development specifically in science instruction (Buczynski & Hansen, 2010). Lastly, instructional leaders are less than supportive when it comes to science instruction, again, due largely to competing demands of high stakes subjects such as Language Arts and Mathematics. Another factor may be that principals themselves do not feel confident in the area of science, and are therefore less likely to make it a focus of their leadership agenda (Posnanski, 2002). Thus, incorporating more stringent science pedagogy requirements for teacher preparation programs, improving professional development practices, and incorporating best practices for science instruction in instructional leadership programs are needed.

Further, national, state, and local policy reforms are needed to improve science education at the elementary level. These policies should focus on the inclusion of science education in reading, writing, and math. I propose three specific policies aimed at improving science education in elementary schools nationwide: A focus on science across the curriculum; a model for science-specific professional development; and inclusion of specific content courses as a requirement in administrative credential programs.

Science Across the Curriculum

While CCSS encourage cross-curricular strategies, there is still much work to be done. Incorporating science across the curriculum needs to become a focus to effect lasting improvements to science instruction at the elementary level. Further, rigorous science education will promote critical thinking skills, required of all students in the CCSS. The inclusion of science in other core instructional areas will help students be better prepared for college and career. An example of this may be the inclusion of science standards in a math lesson. When focusing on perimeter and area, teachers can include a discussion about density, which is the amount of a given substance in a given space. Another example could include reading science-specific informational texts in English Language Arts. In history, studying important discoveries in science throughout time and how they impacted events, such as the industrial revolution or the advent of the

Internet era, would create a real world connection to content for students. Regardless of the connection, a strategic effort to open the content specific silos in which we now work to incorporate science across the curriculum, especially in elementary schools, should be a major focus of policy changes in the United States.

Model for Science-Specific Professional Development

In May of 2014, the California State Superintendent of Public Instruction, Tom Torlakson, convened a team of teachers, parents, and business leaders to set recommendations for innovative practices in the classroom centered on STEM education (STEM Taskforce, 2014). The taskforce concluded that there are seven strategic areas of focus to create a positive effect on STEM education in California (Figure 5). Of the seven recommendations, Number 5 speaks directly to the need for STEM-specific professional development. Thus, the call for STEM-specific professional development has been made, however, as of yet, it has not been fulfilled. The Raising the Bar for STEM Education in California: Preparing Elementary Teachers in a Model, Scalable, STEM-Rich Clinical Setting project was a grant funded effort to implement an effective STEM-specific model of professional development. This clinical model of professional development was very effective at bringing content and pedagogical experts together in an effort to improve STEM education at the elementary level. The model consisted of bringing pre-service and in-service teachers together to learn, plan, and implement STEM content. The professional development was aligned, intentional, differentiated, ongoing, and purposeful.

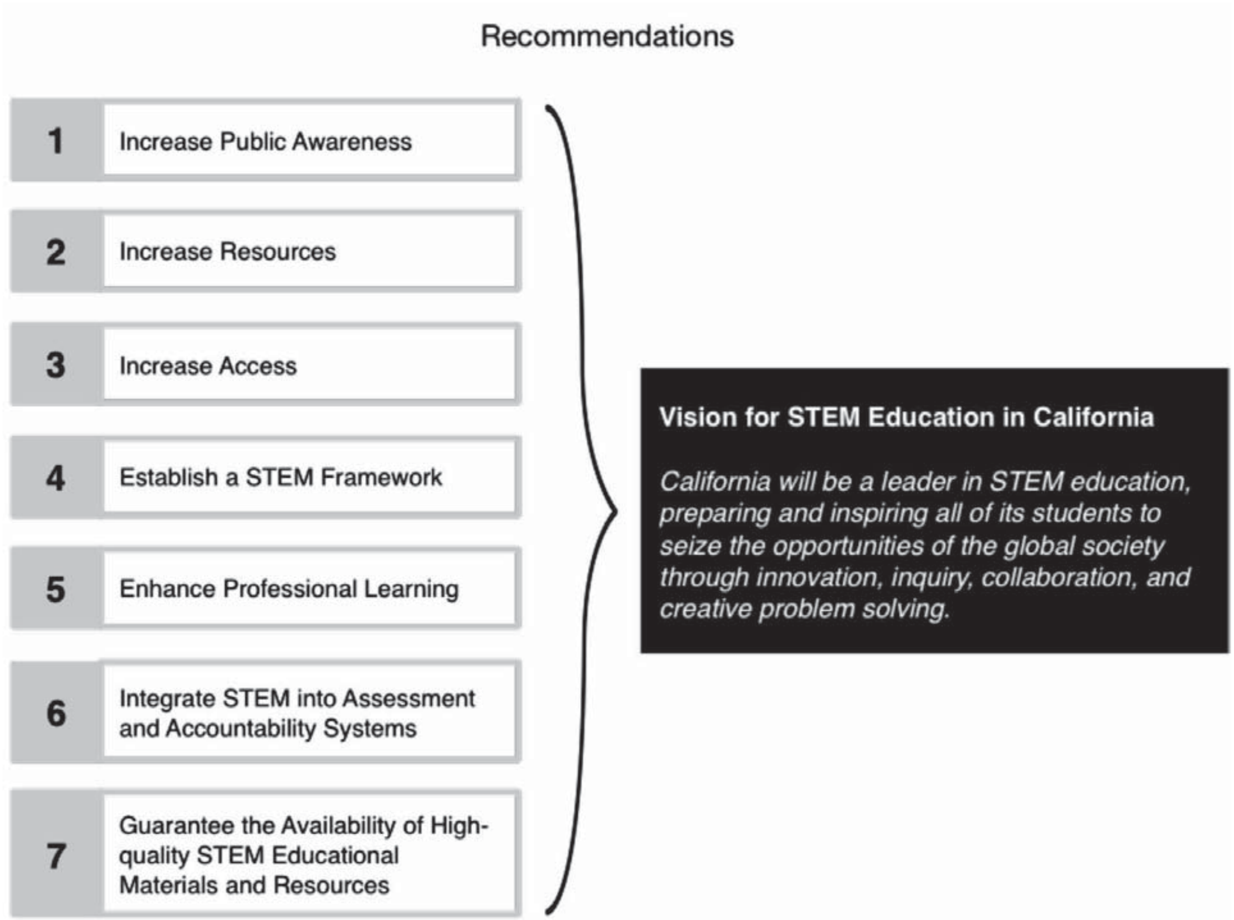

FIGURE 5. STEM taskforce recommendations. CDE STEM Taskforce (2014).

The findings suggest that the STEM-rich professional development was successful in increasing self-efficacy in teaching science. Further, the research points to the most successful portions of the professional development, which were the structure and delivery of the professional development. The structure included a planning phase, an implementation phase, and an evaluation phase. Based on the success of the professional development in increasing self-efficacy in teaching science, I recommend a three-phase approach to designing science-specific professional development, which is essential to the effectiveness of science-specific professional development (Figure 6).

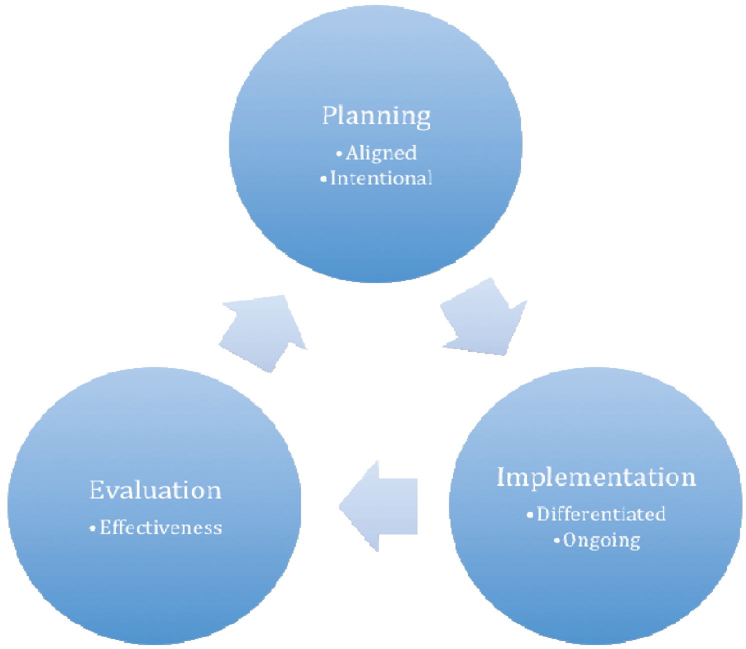

FIGURE 6. Professional development model overview. Overview of professional development model describing three phases of effective science-specific professional development. Trimmell (2015).

First, the professional development should be planned intentionally and should be aligned to current standards. This brings relevance to the professional development and creates a climate of "buy-in" on the part of the participants. Next, the implementation phase of the professional development should include differentiation based on current need and it should be ongoing. Finally, the evaluation of the professional development should include measures of effectiveness and sustainability. As with any good plan, starting with a program logic model increases focus and provides a framework for which to evaluate the effectiveness of the program (Wholey, Hatry, & Newcomer, 2010). Thus, the entire process goes from planning to implementation, to evaluation.

Further, based on the positive findings of this study, I recommend that science-specific professional development must be aligned, intentional, differentiated, ongoing, and purposeful (Figure 7). Because teachers felt that the STEM-rich professional development was successful, I recommend that a similar model be established for all science-specific professional development. Because the focus of this study was on the in-service master teachers, this model is specific to in-service teacher professional development.

Ideally, the professional development is aligned to current national, state, and local standards to increase relevance. Another important consideration is the incorporation of NGSS along with CCSS. With a cross-curricular focus, the professional development becomes more relevant to the participants. If teachers can apply what they have learned across multiple subject areas, then it is more likely that they will implement their newly learned techniques.

Continuing, the more they implement the newly learned techniques, the better they will become at them, thus increasing effectiveness. Further, the professional development should take into account the current testing models. For example, incorporating technology into the professional development is essential as the administration of the new state assessment, development by Smarter Balanced Assessment Consortium (SBAC), is a computer-based assessment. Providing teachers with skills aligned to the needs of SBAC assessment may increase their self-efficacy in teaching these skills to students, thus improving student outcomes.

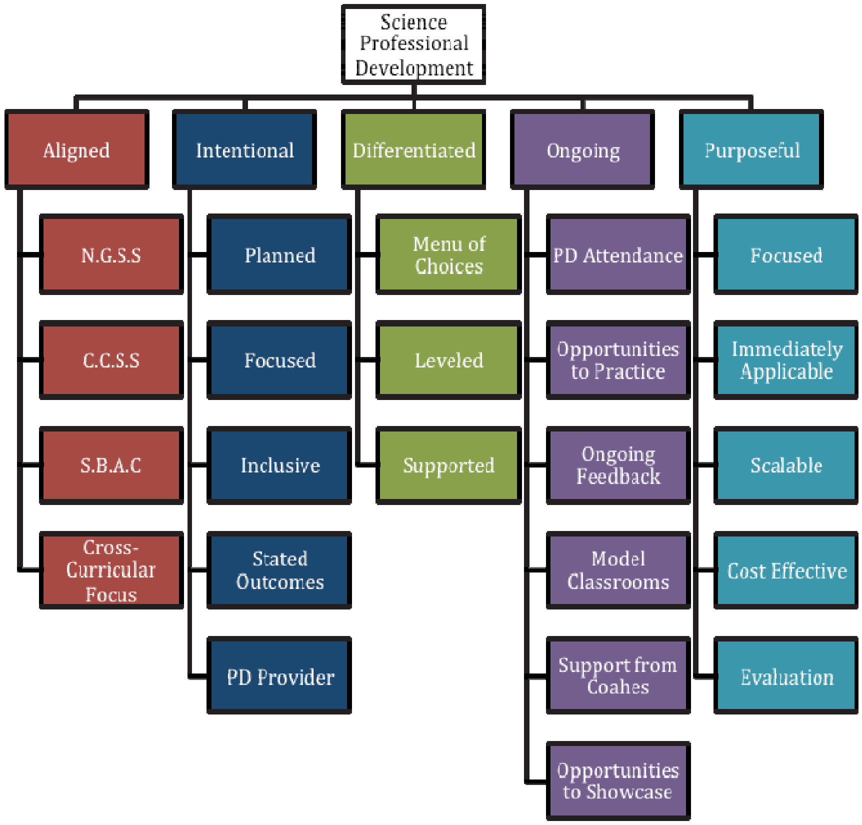

FIGURE 7. Professional development model. Essential components of effective science-specific professional development model. Trimmell (2015).

Next, the professional development must be intentional. The professional development should be planned strategically. This would include selecting an appropriate professional development provider. Depending on the professional capital within the organization, a third party professional development provider may be warranted. However, if there is sufficient professional capital within the organization, in-house professional development providers may be acceptable. Further, the planning must be focused, and the outcomes stated at the onset of the professional development. Finally, the professional development should be inclusive of and applicable to multiple grade levels, including special education.

For the professional development to be inclusive, it must be differentiated. Differentiated professional development should include a menu of choices, should be leveled, and should include differentiated support. The diversity of a group of participants at any professional development will necessitate differentiation based on need. A "one size fits all" approach is antiquated and it dilutes the effects of the professional development. If teachers are given a menu of differentiated options, they will be able to choose a strand that best suits their current needs. The professional development needs of beginning teachers vary greatly from those of veteran teachers. The need, and thus the strand chosen, will depend upon the knowledge base and the professional capital of each individual. Just as the professional development must be differentiated, the strategic support must also be differentiated. The level of support each individual will require after the professional development will differ. No matter the need, support after the professional development is essential. Teachers must be given the opportunity to practice what they learned in a safe environment. The best support option may be the instructional leader, a coach, or a veteran teacher. Support differentiation will depend upon need and the level of trust between the teacher and the support provider. Either way, the support, like the professional development, must be ongoing.

Ongoing professional development allows participants to practice what they have learned in a safe environment. This may be done in a variety of ways. The professional development should be administered over the course of multiple sessions, with time to implement and receive feedback along the way. The feedback may come in the form of support from administrators and/or coaches. It may also include visiting model classrooms where best practices are implemented. After professional development attendance, a support cycle should follow. The support cycle should include a planning module, a lesson observation module, and a lesson-debrief session (Figure 8). In all cases, the trainee and the coach plan and debrief together. The lesson delivery should be done in two phases: The coach delivers the lesson with observation by the trainee, then, the trainee delivers the lesson with observation by the coach. The support cycle is essential to the success of the professional development. The intended benefits may not be realized if strategic support is not provided.

Finally, the professional development must be purposeful. With the end in mind, the professional development must be focused on the needs of the attendees. Also, for highest impact, the professional development should be immediately applicable in the classroom. If teachers are able to use what they have learned in the professional development, they will be more likely to practice it repeatedly. Further, the professional development must be cost effective and scalable. Cost is a major barrier to effective professional development. For a professional development to be successful, it must be scalable to the size and financial abilities of multiple organizations.

Conclusively, we come full circle to the evaluation of the professional development. Was the professional development effective? Some key indicators may include overall participant satisfaction, implementation rates, fidelity to the model, and student outcomes.

<u>Content Specific Requirements in Administrative Credential Programs</u>

Principal instructional leadership is second only to teacher impact on student outcomes (Wahlstrom et al., 2010). The addition of core content specific training for administrative credentialing programs is another implication for policy. Current

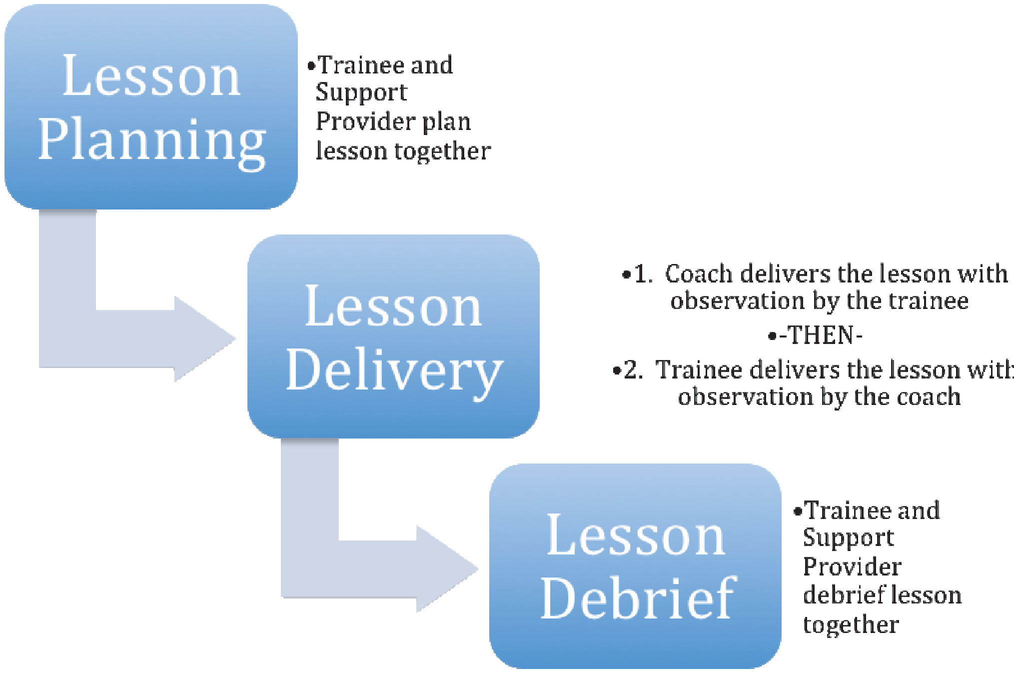

FIGURE 8. Support cycle. Post-professional development support cycle including lesson planning, lesson delivery, and lesson debrief. Trimmell (2015).

administrative credentialing requirements do little to encourage mastery of core content. A key role of the administrator is to observe and coach teachers in lesson design and delivery. Policy makers should create and require higher education institutions to embed mastery benchmarks of core content standards prior to receiving the administrative services credential. This is critical in creating a cadre of highly effective instructional leaders prepared to support teachers in all core content areas. Posnanski (2002) suggests one barrier to implementation of new learning after professional development:

> It is quite possible that the lack of the role of the building principal may have an effect on the outcome expectancies of the participants as they were not required to directly alter their teaching behaviors, nor were they held accountable for representative changes in their students' achievement levels. (p. 212)

Teachers are less likely to apply new teaching strategies when building administrators are not qualified to observe, provide feedback, and ultimately, hold teachers accountable for the implementation of new the teaching strategies. In addition to science education for teachers, instructional leaders should be required to have a basic level of content mastery of core subjects. This will allow them to support teachers in all core content areas.

Implications for Practice

Self-efficacy is an important factor in effective teaching (Bandura, 1977). A major implication for practice should be to increase teachers' sense of self-efficacy in teaching science. The findings of this study suggest that there are four factors of practice that can improve self-efficacy in teaching science: (a) teacher pre-service knowledge of science, (b) professional development, (c) principal instructional leadership, and (d) access to appropriate science resources. Thus, a focus on each of these factors is needed to affect change. Implications for practice include suggestions for teacher credentialing agencies, institutions of higher education, and districts and school-sites.

Teacher Pre-Service Knowledge Around Science

Teacher credentialing agencies, including institutions of higher education, are the focus of improving teacher pre-service knowledge of science. Implications for practice include requiring teacher multiple subject credential candidates to increase their content knowledge of science through intensive science content and pedagogy coursework. As stated in the literature, many teachers lack the background necessary to adequately teach science (Ginns & Watters, 1999). Elementary teacher preparation programs should include or increase science methods courses. An increase in science methods courses could lead to an increase in self-efficacy, and thus, a higher level of implementation once pre-service teachers begin their in-service assignments. Ideally, the science content courses should be tied to real-world practice of the learned content.

Ultimately, pre-service teachers need in-depth pedagogical content knowledge (Figure 9). Shulman (1986) describes PCK (pedagogical content knowledge) as “the ways of representing and formulating the subject that make it comprehensible to others” (p. 9). Pedagogical content knowledge “will allow teachers to know what, when, why, and how to teach using a reservoir of good teaching practices and experience” (Shulman, 1986, p. 9).

Methods courses should also include metacognitive practices aimed at making abstract concepts more concrete. Science contains many abstract concepts that must be concretized to extract meaning. This is difficult if science content is not understood at a conceptual level. Thus, pre-service teachers must learn, internalize, and truly understand science concepts to be able to effectively teach these concepts to their students.

Further, pre-service teachers need opportunities to practice what they are learning. If student teaching is limited to working with master teachers to practice classroom management, reading, writing, and math strategies, they will not be sufficiently prepared to teach science effectively. Placing student teachers in settings where science is a focus will afford them the necessary practice to increase their self-efficacy in teaching science. As student teachers experience successes teaching science (performance outcomes), their self-efficacy will increase, and they will be more likely to continue teaching science efficaciously when they become a teacher of record.

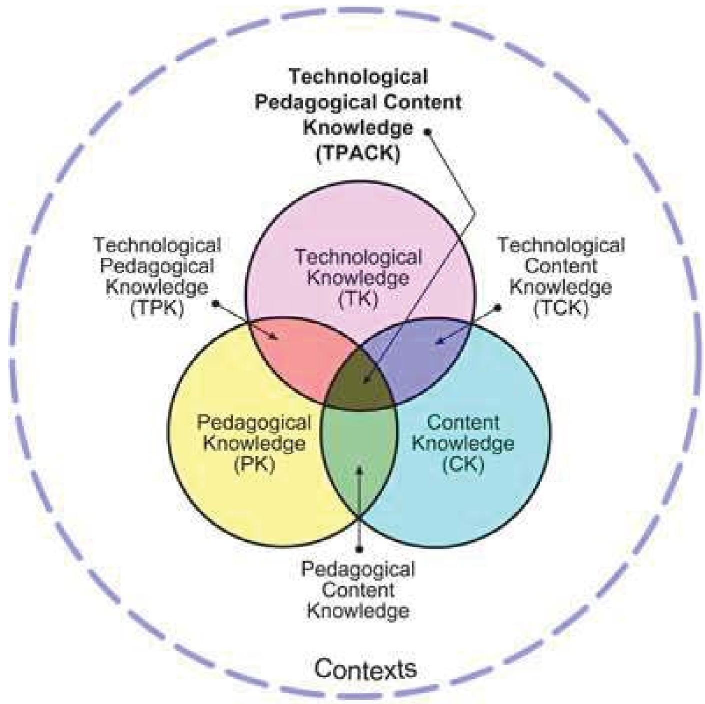

FIGURE 9. Pedagogical content knowledge. The collection of content knowledge, pedagogical knowledge, and technical knowledge. Shulman (1986).

Professional Development

In-service teachers need ongoing professional development to deepen the implementation of best practices in core content areas. While professional development in reading, writing, and math are standard, professional development centered on science is less common. As previously mentioned, science-specific professional development is essential to improving science instruction in elementary schools. Implementation of science-specific professional development is necessary to improve teacher self-efficacy, teacher content knowledge, and teaching practice. The design of the professional development is key and should include multiple factors, such as what occurs during and after the delivery of content. After attending a science-specific professional development activity, teachers should be given ample time to practice the strategies, time to observe model classrooms, and time to evaluate their practice. This will allow teachers to practice and evaluate their implementation of the new strategies and will give them a chance to continually improve their practice. The professional development should also include a strategic and intensive support. The support cycle should include a planning module, a lesson observation module, and a lesson-debrief session. Further, professional development should be aligned, intentional, differentiated, ongoing, and purposeful.

Principal Instructional Leadership

At the district and site levels, the instructional leader is key. The instructional leader can support effective science teaching practices in a variety of ways. First, they should support teacher development in science. This may come in the form of onsite or offsite professional development. Instructional leaders should strategically allocate resources to facilitate the adult learners at their sites. Further, resource allocation should include providing time, space, and appropriate materials for science instruction. Providing time in the schedule for teaching science and for collaborating around science is a practical measure that can be taken. Another key implication for instructional leaders is strategic support. Whether provided by the principal, or by a qualified coach, strategic support is essential to effective instruction. If the principal is not able to provide specific feedback around science instruction, it is imperative that he/she empowers a veteran teacher or a science coach to provide the necessary support. Finally, providing teachers with the appropriate resources for science instruction is also essential.

Access to Appropriate Science Resources

Another leading implication for practice centers on the need to provide adequate resources for science instruction. Science labs, science supplies, and science coaches are among the most important implicating factors that will improve science instruction at the elementary level. Teachers are more likely to teach science effectively when they have the necessary space and supplies to conduct scientific exploration. Further, like with other core content areas, science content experts can act as coaches to support and deepen effective science instruction in the classroom.

Lastly, intentional partnerships between school districts and local higher education teacher preparation programs should be forged to align needs and program requirements. Ideally, local districts and local institutions of higher education meet regularly to discuss the PK-16 pipeline and to vertically articulate the curriculum. Specifically, teacher preparation programs should host meetings with local PK-12 school leaders to align current teaching practices and current needs with teacher preparation instruction. This would be most effectively implemented if teacher preparation programs imbedded core teaching strategies currently used in local PK-12 school districts into methods and content courses. This will better prepare teachers to align the delivery of complex science content with the current methodological expectations of local districts.

Implications for Research

There is a need to further explore the factors that positively affect self-efficacy in teaching science. Additionally, it is unclear if self-efficacy alone is sufficient to improve overall science teaching practice at the elementary level. Research specifically aimed at the factors affecting teachers' sense of self-efficacy in teaching science can help determine the best course of action for teacher credentialing programs, professional development programs, and instructional leaders working in the field.

The current research on the lack of science education required by teacher credentialing programs is conclusive, but not exhaustive (Gess-Newsome, 2001; Ginns & Watters, 1999; Hoachlander & Yanofsky, 2011). Further studies that measure the effects of science pedagogical content knowledge on self-efficacy are needed to influence teacher-credentialing programs. If an increase in self-efficacy, due to exposure to science pedagogical content knowledge, can be shown, policy makers and practitioners alike will be influenced to place an emphasis on science pedagogical content knowledge at the pre-service level. As for the research on the effects of professional development on self-efficacy, the research is less conclusive.

Although professional development has been shown to increase self-efficacy (Akerson & Hanuscin, 2007; Bell & Gilbert, 1994; Buczynski & Hansen, 2010; Grigg et al., 2013; Johnson & Fargo, 2010), there is a need to further investigate which types of professional development best address the needs of science education at the elementary level. Specifically, further research on clinical models of professional development is needed. Also, while the proposed science professional development model described herein is based on the study findings, research to quantitatively and qualitatively validate the model are needed. Additionally, research into the sustainability of grant-funded professional development models will aide organizations of different sizes to scale and replicate successful professional development models. Studying the affects of these different types of professional development on self-efficacy in teaching science can inform policy makers and professional development experts on ways to create highly effective models for science professional development. Further, longitudinal studies, including student test data, may inform leaders as to the effectiveness of a particular professional development. While research focusing on large-scale professional development is needed, specific professional development and collaboration time at the district and site level are equally important. This brings to the forefront the need for effective instructional leaders in the area of science education.

Inquiry into the effects of effective leadership on self-efficacy in science teaching is needed to inform experts of best practices. Exploring best practices currently employed at the district and site levels will expose effective practices that can be duplicated. Additionally, studying the effects of inclusion of instructional leaders in science-specific professional development on their ability to effectively support science instruction may prove both interesting and insightful. The research in this area can also transcend science education and be a model for effective principal leadership in general. These studies can be both qualitative and quantitative in nature, as they will produce a more robust understanding of best practices currently employed in the field.

Finally, there are some more pragmatic examples that would be interesting to study. For example, how could thematic units of instruction affect self-efficacy in teaching science? Also, does self-efficacy play as major a role when science is taught through thematic units? Further, it will be important to study the key instructional practices that are specific to science instruction. Research into best practices and evidence-based teaching strategies specific to science may increase self-efficacy in teaching science for teachers.

Limitations of the Study

As listed in Chapter 1, there are some limiting factors associated with this study. Of the limiting factors listed, three prominent factors arose after analyzing the data. First, the small sample size of this study does not allow for generalizability. Though the results, in all but one instance, were statically significant, it can be assumed that the results are limited to the sample studied. Second, the nature of the survey data may have led to inflation of self-reported self-efficacy scores. This may be due in part to the perception of increased knowledge following the professional development. A longitudinal study, including student scores, could potentially more accurately characterize the increase in self-efficacy. Finally, because participants in both the focus group and the experimental group self-selected into the study, they may have come with higher levels of self-efficacy in teaching science to begin with. To control for such factors, a true experimental design with randomization of participants into a control and an experimental group should be conducted.

Conclusion

This chapter has focused on implications and recommendations for policy, for practice, and for research. Major implications for policy include three specific policies aimed at improving science education in elementary schools nationwide: A focus on science across the curriculum; a model for science-specific professional development; and inclusion of specific content courses as a requirement in administrative credential programs. Incorporating science across the curriculum will make science more relevant to students and more practical for teachers. A science professional development model was suggested that requires at its core that the professional development be aligned, intentional, differentiated, ongoing, and purposeful. Finally, content specific requirements should be added to administrative credential programs. Administrators need to be able to support teachers through observation, coaching, and accountability measures. Gaps in administrator's specific content knowledge must be filled so they can effectively support teachers with their practice. Major implications for practice include improving teachers' pre-service knowledge of science. Incorporating and/or improving science pedagogical content knowledge instruction in credentialing programs may accomplish this. Improving science-specific professional development is another implication for practice. First, making science-specific professional development available is essential. Equally important is ensuring the appropriate professional development model be employed. The professional development should be aligned, intentional, differentiated, ongoing, and purposeful. Another implication for practice is increasing instructional leaders' capacity to support effective science-teaching practices. Finally, providing teachers with appropriate science supplies to effectively teach science is essential.

Future research should be conducted to further explicate the factors that most effect self-efficacy in teaching science. The identification of these factors may lead to a better understanding of how to support teachers to effectively teach science. Further research into the interconnectedness of pedagogical content knowledge support and effective teaching practices is also warranted. Another focus of future research should include the evaluation of current and proposed models of science-specific professional development. Lastly, investigation into the effects of effective leadership on self-efficacy in teaching science is needed to know how instructional leaders can best support science teaching.

APPENDICES

APPENDIX A

SURVEY INSTURMENT (STEBI)

Appendix A

Science Teaching Efficacy Beliefs Instrument

PRE/POST SURVEY

Science Teaching Efficacy and Beliefs Instrument Enochs, L. G., & Riggs, I. M. (1990).

This instrument was designed by science educators to measure some of your feelings about science teaching.
Please indicate the degree to which you agree or disagree with each statement below by circling the appropriate letters to the right of each statement.

SA = STRONGLY AGREE
A = AGREE
UN = UNCERTAIN
D = DISAGREE
SD = STRONGLY DISAGREE

1. When a student does better than usual in science, it is often because the teacher exerted a little extra effort.	SA A UN D SD
2. I will continually find better ways to teach science.	SA A UN D SD
3. Even if I try very hard, I will not teach science as well as I will most subjects.	SA A UN D SD
4. When the science grades of students improve, it is often due to their teacher having found a more effective teaching approach.	SA A UN D SD
5. I know the steps necessary to teach science concepts effectively.	SA A UN D SD
6. I will not be very effective in monitoring science experiments.	SA A UN D SD
7. If students are underachieving in science, it is most likely due to ineffective science teaching.	SA A UN D SD
8. I will generally teach science ineffectively.	SA A UN D SD
9. The inadequacy of a student's science background can be overcome by good teaching.	SA A UN D SD
10. The low achievement of some students cannot generally be blamed on their teachers.	SA A UN D SD
11. When a low-achieving child progresses in science, it is usually due to extra attention given by the teacher.	SA A UN D SD

12. I understand science concepts well enough to be effective in teaching science.	SA A UN D SD
13. Increased effort in science teaching produces little change in some students' science achievement.	SA A UN D SD
14. The teacher is generally responsible for the achievement of students in science.	SA A UN D SD
15. Students' achievement in science is directly related to their teacher's effectiveness in science teaching.	SA A UN D SD
16. If parents comment that their child is showing more interest in science at school, it is probably due to the performance of the child's teacher.	SA A UN D SD
17. I will find it difficult to explain to students why science experiments work.	SA A UN D SD
18. I will typically be able to answer students' science questions.	SA A UN D SD
19. I wonder if I will have necessary skills to teach science.	SA A UN D SD
20. Effectiveness in science teaching has little influence on the achievement of students with low motivation.	SA A UN D SD
21. Given a choice, I will not invite the principal to evaluate my science teaching.	SA A UN D SD
22. When a student has difficulty understanding a science concept, I will usually be at a loss as to how to help the student understand it better.	SA A UN D SD
23. When teaching science, I will usually welcome student questions.	SA A UN D SD
24. I do not know what to do to turn students on to science.	SA A UN D SD
25. Even teachers with good science teaching abilities cannot help some kids to learn science.	SAA UN D SD

THE END

APPENDIX B

FOCUS GROUP INTERVIEW PROTOCOL

Appendix B

Experimental and Focus Group Interview Protocol

1. Tell me about your teaching experience.
2. Reflecting on your credential program, and on your pre-service student teaching, how well were you prepared to teach science?
3. Do you belong to any professional associations? Have they supported your science instruction in any way?
4. What individual support has your principal given you to improve your science teaching?
5. What types of professional development, specifically in science, have you attended?
6. How has this professional development affected your classroom practice?
7. Could you share with me what you like about teaching science?
8. Could you share with me anything that you do not like about teaching science?
9. Why do you think some teachers have more confidence teaching science than other teachers?
10. What would you say is the most important thing that would make you feel more confident about teaching science?
11. Is there anything else that you would like to add?

Additional Demographic Information To Be Collected:

Current Grade Level
Number of Years Elementary Teaching
Years at Current Site
Number of Years with Current Principal
Gender
Undergraduate Major
Number of Science Courses Taken at the University Level

APPENDIX C

INFORMED CONSENT—TREATMENT GROUP

Appendix C

Informed Consent Treatment Group

CONSENT TO PARTICIPATE IN RESEARCH

The Effects of STEM-Rich Clinical Professional Development on Teachers' Sense of Self-Efficacy in Teaching Science

You are being invited to participate in a research study conducted by Michael Trimmell, M.Ed, a doctoral candidate, from the Department of Educational Leadership at California State University, Long Beach. You were selected as a possible participant in this study because you participated in the STEM professional development program sponsored by the S.D. Bechtel, Jr. Foundation as a university supervisor of master and student teachers. Your participation in the study will greatly increase understanding of science teaching in the elementary school setting.

PURPOSE OF THE STUDY

The purpose of this study is to evaluate the impact of the yearlong professional development program on teachers' self-efficacy in teaching science.

PROCEDURES

If you volunteer to participate in this study, you will do the following things:

1. Participate in an interview.
2. You are not required to participate in the interview if you choose not to.

POTENTIAL RISKS AND DISCOMFORTS

There are no major risks or hazards if you participate in this research. Since your name will remain anonymous in any write-up of the project, you should not be worried about being identified. You are assured that any results will not be used for evaluative purposes, and will not be shared with university, school or district administration. Additionally, you may choose not to respond to any question that makes you feel uncomfortable or choose to discontinue your participation at any time without negatively affecting your employment or student status. Finally, data will be stored in a locked file cabinent in Michael Trimmell's office and/or on password protected computer in password protected files.

POTENTIAL BENEFITS TO SUBJECTS AND/OR TO SOCIETY

You will possibly benefit from the research by being able to measure your self-efficacy in teaching science.

You will possibly benefit by reflecting on the survey items and/or discussing them with colleagues.

CONFIDENTIALITY

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law. A number will be assigned to your survey in advance of administration and used instead of your name during statistical analysis. The number assigned to you and the key connecting your number to your name will be kept in a locked file cabinet in Michael Trimmell's office.

Results from the surveys will be summarized in a dissertation as partial fulfillment of the requirements for the degree of Doctor on Education. All names will remain confidential in the reports.

Data will be stored in a locked file cabinens in Michael Trimmell's office and/or on a password protected computer in password protected files.

PARTICIPATION AND WITHDRAWAL

You can choose whether to be in this study or not. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. Participation or non-participation will not affect your career in any way. You may also refuse to answer any questions you don't want to answer and still remain in the study.

IDENTIFICATION OF INVESTIGATORS

If you have any questions or concerns about the research, please feel free to contact Dr. Linda Symcox at 562-985-1147 or via email at: linda.symcox@csulb.edu or Michael Trimmell at (XXX) XXX-XXXX or via email: XXX@gmail.com.

RIGHTS OF RESEARCH SUBJECTS

You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your rights as a research subject, contact the Office of University Research, CSU Long Beach, 1250 Bellflower Blvd., Long Beach, CA 90840; Telephone: (562) 985-5314 or email to research@csulb.edu.

SIGNATURE OF RESEARCH SUBJECT

I understand the procedures and conditions of my participation described above. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.

Printed Name of Subject ________________________________

Signature of Subject ________________________________ Date

____

Please initial on the following lines if you agree to the medium that will be utilized in this study:

Audio recording ______ Interview ______

APPENDIX D

EMAIL SCRIPT

Appendix D

Email Script

Dear Master Teacher,
I am a doctoral student at California State University, Long Beach. I am studying elementary teachers' opinions on the teaching of science in the classroom. I am requesting your participation in a short online survey that should take no more than 10 – 15 minutes of your time.
Your views on teaching science in elementary schools will provide valuable information about how we teach science and how teachers feel about their preparedness to teach science.
As stated, the survey will take 10 – 15 minutes to complete. Please try to answer all of the questions. Your name will not be requested for the survey and no identifying information will be used in the study. No teacher, administrator, or school in the study will be identified. All responses are strictly confidential.
If you would like to participate, please click on the secure link below.
https://www.surveymonkey.com/s/GWWFX27)
After completing the survey, you will be directed to an additional page to receive a $10 Starbucks gift card to show my appreciation for your participation in this important study.
Thank you for you time and participation.
Sincerely,

Michael Trimmell
California State University, Long Beach Doctoral Candidate.
Tel: (XXX) XXX-XXXX. Email: XXX@gmail.com.
Doctoral Supervisor: Dr. Linda Symcox, Tel: (562) 985-1147. Email: linda.symcox@csulb.edu

APPENDIX E

SURVEY MONKEY ACTIVE LINK

Appendix E

Active Survey Link

Survey Monkey Active Link to Survey:

https://www.surveymonkey.com/s/GWWFX27

APPENDIX F

VERBAL SCRIPT

Appendix F

Verbal Script

Dear Master Teacher,
I am a doctoral student at California State University, Long Beach. I am studying elementary teachers' opinions on the teaching of science in the classroom. I am requesting your participation in a short focus group interview that should take no more than 20 - 30 minutes of your time.
Your views on teaching science in elementary schools will provide valuable information about how we teach science and how teachers feel about their preparedness to teach science.
As stated, the focus group will take 20 – 30 minutes of your time. Participation is strictly voluntary. There is no obligation and there is no penalty for not participating. Your name will not be requested for the interview and no identifying information will be used in the study. No teacher, administrator, or school in the study will be identified. All responses are strictly confidential.
If you would like to participate, please join me in the back of the room so that I can provide you with and discuss with you an informed consent form.
After completing the focus group interview, you will be given a $10 Starbucks gift card to show my appreciation for your participation in this important study.
Thank you for you time and participation.
Michael Trimmell
California State University, Long Beach Doctoral Candidate.
Tel: (XXX) XXX-XXXX. Email: XXX@gmail.com.
Doctoral Supervisor: Dr. Linda Symcox, Tel: (562) 985-1147. Email:
linda.symcox@csulb.edu

APPENDIX G

INFORMED CONSENT—FOCUS GROUP INTERVIEW

Appendix G

Informed Consent – Focus Group Interview

CONSENT TO PARTICIPATE IN RESEARCH

The Effects of STEM-Rich Clinical Professional Development on Teachers' Sense of Self-Efficacy in Teaching Science

You are being invited to participate in a research study conducted by Michael Trimmell, M.Ed, a doctoral candidate, from the Department of Educational Leadership at California State University, Long Beach. You were selected as a possible participant in this study because you are a master teacher working with CSULB multiple subject credential students. Your participation in the study will greatly increase understanding of science teaching in the elementary school setting.

PURPOSE OF THE STUDY

The purpose of this study is to evaluate the impact of the yearlong professional development program on teachers' self-efficacy in teaching science.

PROCEDURES

If you volunteer to participate in this study, you will do the following things:

3. Participate in a focus group interview.
4. You are not required to participate in the focus group interview if you choose not to.
5. The focus group will take approximately 30 minutes.
6. The session will be audio taped and handwritten notes will be taken.

POTENTIAL RISKS AND DISCOMFORTS

There are no major risks or hazards if you participate in this research. Since your name will remain anonymous in any write-up of the project, you should not be worried about being identified. You are assured that any results will not be used for evaluative purposes, and will not be shared with university, school or district administration. Additionally, you may choose not to respond to any question that makes you feel uncomfortable or choose to discontinue your participation at any time without negatively affecting your employment or student status. Also, if you do not wish to be audio recorded, only hand written notes will be taken. Finally, data will be stored in a locked file cabinent in Michael Trimmell's office and/or on password protected computer in password protected files.

POTENTIAL BENEFITS TO SUBJECTS AND/OR TO SOCIETY

There are no direct benefits to you from participating in this research study. However, you may have the opportunity to reflect on your own learning and to measure your own professional growth.

PAYMENT FOR PARTICIPATION

All participants will receive a $15 Starbucks gift card for their participation in the focus group. You will receive the gift card even if you choose to leave prior to completion of the focus group interview.

CONFIDENTIALITY

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law. You will be assigned a pseudonym to protect your identity. You will have access to the interview transcripts to check for accuracy. The audio recording will be destroyed immediately upon completion of transcription. All written material will be destroyed three years after completion of the study.
A copy of their signed consent form will be submitted to and remain on file with the LBUSD Research Office Administrator.
Results from the surveys will be summarized in a dissertation as partial fulfillment of the requirements for the degree of Doctor on Education. All names will remain confidential in the reports.
Data will be stored in a locked file cabinens in Michael Trimmell's office and/or on a password protected computer in password protected files. Only Michael Trimmell and Linda Symcox will have access to the data.
PARTICIPATION AND WITHDRAWAL
You can choose whether to be in this study or not. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. Participation or non-participation will not affect your career in any way. You may also refuse to answer any questions you don't want to answer and still remain in the study. You may also review the transcripts upon request.
IDENTIFICATION OF INVESTIGATORS
If you have any questions or concerns about the research, please feel free to contact Dr. Linda Symcox at 562-985-1147 or via email at: linda.symcox@csulb.edu or Michael Trimmell at (XXX) XXX-XXXX or via email: XXX@gmail.com.
RIGHTS OF RESEARCH SUBJECTS
You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your rights as a research subject, contact the Office of University Research, CSU Long Beach, 1250 Bellflower Blvd., Long Beach, CA 90840; Telephone: (562) 985-5314 or email to irb@csulb.edu.
SIGNATURE OF RESEARCH SUBJECT
I understand the procedures and conditions of my participation described above. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.
Printed Name of Subject ___________________________________
Signature of Subject ___________________________________ Date
____
Please initial on the following lines if you agree to the medium that will be utilized in this study:
Audio recording ______

APPENDIX H

STUDENT TEACHER COORDINATOR INTERVIEW PROTOCOL

Appendix H

Student Teacher Coordinator Interview Protocol

1. Please describe for me your relationship with the master teachers.
2. Which aspects of the STEM PD had the most impact?
3. What impact, if any, did the STEM PD have on master teachers?
4. Can you think of any examples of a renewed interest in, or an increased interest in science as a result of the STEM PD?
5. What types of supports do master teachers need to effectively guide student teachers in science instruction?
6. What types of PD to you think the master teachers find most effective?
7. What have you observed in terms of science lesson preparation between master and student teacher?
8. What would you say are some roadblocks to increased science teaching in elementary schools?
9. What were the biggest complaints and highest praises about the STEM PD that you heard over the two years?
10. If you were to redesign the STEM PD, keeping the master teachers in mind, what would you keep, what would you lose, and what would you add?

REFERENCES

REFERENCES

Akerson, V. L., & Hanuscin, D. L. (2007). Teaching nature of science through inquiry: Results of a 3-year professional development program. *Journal of Research in Science Teaching*, *44*(5), 653–680.

Akerson, V. L., & McDuffie, A. R. (2002, January 10–13). *The elementary science teacher as researcher*. Paper presented at the Annual International Conference of the Association of the Education of Teachers in Science, Charlotte, NC.

Allinder, R. M. (1995). An examination of the relationship between teacher efficacy and curriculum-based measurement and student achievement. *Remedial & Special Education, 16*(4), 247–285.

Arambula-Greenfield, T., & Feldman, A. (1997). Improving science teaching for all students. *School Science and Mathematics, 97*(7), 377–386.

Ashton, P. T., & Webb, R. B. (1986). *Making a difference: Teachers' sense of efficacy and student achievement*. New York, NY: Longman.

Au, W. (2011). Neither fair nor accurate: Research-based reasons why high-stakes tests should not be used to evaluate teachers. *Rethinking Schools*, *25*(2), 34–38.

Avery M. L., & Carlsen S. W. (2001, March 28). *Knowledge, identity, and teachers' multiple communities of practice*. Paper presented at the annual meeting of the National Association for Research in Science Teaching, St. Louis, MO.

Bandura, A. (1977). *Social learning theory*. Englewood Cliffs, NJ: Prentice Hall.

Bandura, A. (1982). The assessment and predictive generality of self-percepts of efficacy. *Journal of behavior therapy and experimental psychiatry*, *13*(3), 195–199.

Bandura, A. (1986). *Social foundations of thought and action*. Englewood Cliffs, NJ: Prentice-Hall.

Bandura, A. (1989). Human agency in social cognitive theory. *American Psychologist*, *44*(9), 1175.

Bandura, A. (1993). Perceived self-efficacy in cognitive development and functioning. *Educational Psychologist*, *28*(2), 117–148.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York, NY: Freeman.

Bandura, A. (2001). Social cognitive theory: An argentic perspective. *Annual Review of Psychology*, *52*, 1–26.

Beatty, B. R. (2000). The emotions of educational leadership: Breaking to silence. *International Journal of Leadership in Education, 13*(4), 331–357.

Bell, B., & Gilbert, J. (1994). Teacher development as professional, personal, and social development. *Teaching and Teacher Education*, *10*(5), 483–497.

Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational Researcher*, *33*(8), 3–15.

Boyd, D., Lankford, H., Loeb, S., Rockoff, J., & Wyckoff, J. (2008). The narrowing gap in New York City teacher qualifications and its implications for student achievement in high-poverty schools. *Journal of Policy Analysis and Management*, *27*(4), 793–818.

Buczynski, S., & Hansen, C. B. (2010). Impact of professional development on teacher practice: Uncovering connections. *Teaching and Teacher Education, 26*(3), 599–607.

Cakiroglu, J., Capa-Aydin, Y., & Hoy, A. W. (2012). Science teaching efficacy beliefs. In B. J. Fraser, K. Tobin, & C. J. McRobbie (Eds.), *Springer International Handbooks of Education : Vol. 24. Second international handbook of science education* (pp. 449–461). doi:10.1007/978-1-4020-9041-7_31

California Board of Education. (2012). *California Board of Education*. Sacramento, CA: CDE Press.

California Commission on Teacher Credentialing (CCTC). (2009). *California standards for the teaching profession*. Sacramento, CA: Author.

California Department of Education, STEM Task Force. (2014, May 1). *INNOVATE: A blueprint for science, technology, engineering, and mathematics in California public education: A report by State Superintendent of Public Instruction Tom Torlakson's STEM Task Force*. Retrieved from http://www.cde.ca.gov/pd/ca/sc/documents/innovate.pdf

Calik, T., Sezgin, F., Kavgachi, H., & Kilinc, A. (2012). Examination of relationships between instructional leadership of school principals and self-efficacy of teachers and collective teacher efficacy. *Educational Sciences: Theory & Practice*, *12*(4), 2498–2504.

Carey, M. A. (1994). The group effect in focus groups: Planning, implementing, and interpreting focus group research. In J. Morse (Ed.), *Critical Issues in Qualitative Research Methods* (pp. 225–251). Thousand Oaks, CA: Sage.

Carnevale, A. P., Smith, N., & Melton, M. (2011). *STEM: Science technology engineering mathematics*. Washington, DC: Georgetown University Center on Education and the Workforce.

Chiseri-Strater, E. (1996). Turning in upon ourselves: Positionality, subjectivity, and reflexivity in case study and ethnographic research. In P. Mortensen & G. Kirsch (Eds.), *Ethics and representation in qualitative studies of literacy* (pp. 115–133). Urbana, IL: National Council of Teachers of English.

Cohen, D. K., & Hill, H. C. (1998). *State policy and classroom performance: Mathematics reform in California* (CPRE Policy Briefs RB-23-May). Philadelphia, PA: Consortium for Policy Research in Education (CPRE), Graduate School of Education, University of Pennsylvania.

Cohen, J. (1988). *Statistical power of analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Erlbaum.

Cohen, J. (1992). A power primer. *Psychological Bulletin*, *112*(1), 155.

College of Education (CED). (2014). *ITEP Multiple Subject UTEACH Option*. Retrieved July 15, 1014, from http://www.ced.csulb.edu/teacher-ed/academic/mscp/itep-multiple-subject-uteach-option

Crawford, B. A. (2007). Learning to teach science as inquiry in the rough and tumble of practice. *Journal of Research in Science Teaching*, *44*(4), 613–642.

Creswell, J. W., & Clark, V. L. P. (2010). *Designing and conducting mixed methods research* (2nd ed.). Thousand Oaks, CA: Sage

Darling-Hammond, L. (2000). Teacher quality and student achievement. *Education Policy Analysis Archives*, *8*, 1–44.

Darling-Hammond, L. (2006). Constructing 21st-century teacher education. *Journal of Teacher Education*, *57*(3), 300–314.

Darling-Hammond, L. (2010). Teacher education and the American future. *Journal of Teacher Education, 61*(1/2), 35–47.

Darling-Hammond, L. (2012). *Powerful teacher education: Lessons from exemplary programs*. Hoboken, NJ: Wiley.

Davis, E. A., & Smithey, J. (2009). Beginning teachers moving toward effective elementary science teaching. *Science Education*, *93*(4), 745–770.

Davis, S., Darling-Hammond, L., LaPointe, M., & Meyerson, D. (2005). *School leadership study: Developing successful principals*. Stanford, CA: Stanford Educational Leadership Institute.

Department of Defense (DoD). (2009). *Science, technology, engineering and mathematics: STEM education and outreach strategic plan*. Washington, DC: Author.

Dorph, R., Shields, P., Tiffany-Morales, J., Hartry, A., & McCaffrey, T. (2011). *High hopes–few opportunities: The status of elementary science education in California*. Sacramento, CA: The Center for the Future of Teaching and Learning at WestEd.

Druva, C. A., & Anderson, R. D. (1983). Science teacher characteristics by teacher behavior and by student outcome: A meta-analysis of research. *Journal of Research in Science Teaching*, *20*(5), 467–479.

Duncan, A. (2010). Chicago's renaissance 2010: Building on school reform in the age of accountability. *Phi Delta Kappan*, *87*(6), 457–458.

Edmonds, R. (1979). Effective schools for the urban poor. *Educational leadership*, *37*(1), 15–24.

Enochs, L. G., & Riggs, I. M. (1990). Further development of an elementary science teaching efficacy belief instrument: A pre-service elementary scale. *School Science and Mathematics, 90*(8), 694–706.

Ferguson, R. (1991). Paying for public education: New evidence on how and why money matters. *Harvard Journal on Legislation, 28*, 465–498.

Fishman, B., Konstantopoulos, S., Kubitskey, B. W., Vath, R., Park, G., Johnson, H., & Edelson, D. C. (2013). Comparing the impact of online and face-to-face professional development in the context of curriculum implementation. *Journal of Teacher Education*, *64*(5), 426–438.

Friedman, I. A. (2003). Self-efficacy and burnout in teaching: The importance of interpersonal-relations efficacy. *Social Psychology of Education, 6*(3), 191–215.

Gess-Newsome, J. (2001). The professional development of science teachers for science education reform: A review of the research. In J. Rhoton & P. Bowers (Eds.), *Professional development: Planning and design* (pp. 91-100). Arlington, VA: NSTA Press.

Ginns, I. S., & Watters, J. J. (1999). Beginning elementary school teachers and the effective teaching of science. *Journal of Science Teacher Education, 10*(4), 287–313.

Goddard, R. D., Hoy, W. K., & Hoy, A. W. (2000). Collective teacher efficacy: Its meaning, measure, and impact on student achievement. *American Educational Research Journal*, *37*(2), 479–507.

Greene, J. C. (2007). Toward a methodology of mixed methods social inquiry. *Research in the Schools, 13*(1), 93–98

Gregoire, M. (2003). Is it a challenge or a threat? A dual process model of teachers' cognition and appraisal processes during conceptual change. *Educational Psychology Review, 15*, 147–179.

Grigg, J., Kelly, K. A., Gamoran, A., & Borman, G. D. (2013). Effects of two scientific inquiry professional development interventions on teaching practice. *Educational Evaluation and Policy Analysis, 35*(1), 38–56. doi:10.3102/0162373712461851

Hallinger, P., & Heck, R. H. (2002). What do you call people with visions? The role of vision, mission and goals in school leadership and improvement. In K. Leithwood & P. Hallinger (Eds.), *Second international handbook of educational leadership and administration* (pp. 9–40). Boston, MA: Kluwer.

Hechter, R. P. (2011). Changes in pre-service elementary teachers' personal science teaching efficacy and science teaching outcome expectancies: The influence of context. *Journal of Science Teacher Education, 22*(2), 187–202.

Hesse-Biber, S. N., & Leavy, P. (2011). Focus group interviews. In S. N. Hesse-Biber & P. Leavy (Eds.), *The practice of qualitative research* (2nd ed., pp. 163–192). Thousand Oaks, CA: Sage.

Hipp, K. A. (1997). *Documenting the effects of transformational leadership behavior on teacher efficacy*. Retrieved from ERIC database. (ED407734)

Hoachlander, G., & Yanofsky, D. (2011). Making STEM real. *Educational Leadership*, *68*(6), 1–6.

Hoy, A. W., & Spero, R. B. (2005). Changes in teacher efficacy during the early years of teaching: A comparison of four measures. *Teaching and Teacher Education*, *21*(4), 343–356.

Jacob, S. A., & Furgerson, S. P. (2012). Writing interview protocols and conducting interviews: Tips for students new to the field of qualitative research. *The Qualitative Report*, *17*(42), 1–10.

Johnson, C. C. (2007). Whole-school collaborative sustained professional development and science teacher change: Signs of progress. *Journal of Science Teacher Education*, *18*(4), 629–661.

Johnson, C. C., & Fargo, J. D. (2010). Urban school reform enabled by transformative professional development: Impact on teacher change and student learning of science. *Urban Education, 45*(1), 4–29.

Keys, C. W., & Bryan, L. A. (2001). Co-constructing inquiry-based science with teachers: Essential research for lasting reform. *Journal of Research in Science Teaching, 38*, 631–645.

Killian, J. R., Jr. (1959). Science and public policy: Recent actions by the Federal Government in helping science and technology help the nation are surveyed. *Science*, *129*(3342), 129–138.

Knight, P. (2002). A systemic approach to professional development: Learning as practice. *Teaching and teacher education*, *18*(3), 229–241.

Komarraju, M. (2013). Ideal teacher behaviors: student motivation and self-efficacy predict preferences. *Teaching of Psychology*, *40*(2), 104–110.

Lee, C. A., & Housel, A. (2003). Self-efficacy, standards, and benchmarks as factors in teaching elementary school science. *Journal of Elementary Science Education, 15*, 37–55.

Leont'ev, A. N. (1974). The problem of activity in psychology. *Journal of Russian and East European Psychology*, *13*(2), 4–33.

Luft, P., Brown, C. M., & Sutherin, L. J. (2007). Are you and your students bored with the benchmarks? Sinking under the Standards? Then transform your teaching through transition! *Teaching Exceptional Children*, *39*(6), 39–46.

Lumpe, A., Czerniak, C., Haney, J., & Beltyukova, S. (2012). Beliefs about teaching science: The relationship between elementary teachers' participation in professional development and student achievement. *International Journal of Science Education*, *34*(2), 153–166.

Mansfield, C. F., & Woods-McConney, A. (2012). "I didn't always perceive myself as a 'science person'": Examining efficacy for primary science teaching. *Australian Journal of Teacher Education*, *37*(10), 17–37.

Marx, R. W., & Harris, C. J. (2006). No Child Left Behind and science education: Opportunities, challenges, and risks. *The Elementary School Journal*, *106*(5), 467–478.

Marzano, R. J., Waters, T., & McNulty, B. A. (2005). *School leadership that works: From research to results*. Alexandria, VA: Association for Supervision and Curriculum Development.

Meyer, H., Tabachnick, B. R., Hewson, P. W., Lemberger, J., & Park, H. J. (1999). Relationships between prospective elementary teachers' classroom practice and their conceptions of biology and of teaching science. *Science Education*, *83*(3), 323–346.

Mintzes, J. J., Marcum, B., Messerschmidt-Yates, C., & Mark, A. (2012). Enhancing self-efficacy in elementary science teaching with professional learning communities. *Journal of Science Teacher Education*, *24*(7), 1201–1218.

Morgan, D. L. (1996). Focus groups. *Annual review of sociology, 22*, 129–152.

Mulholland, J., & Wallace, J. (2001). Teacher induction and elementary science teaching: Enhancing self-efficacy. *Teaching and Teacher Education, 17*(2), 243–261.

Munby, H., Russell, T., & Martin, A. K. (2001). Teachers' knowledge and how it develops. *Handbook of research on teaching*, *4*, 877–904.

Murphy, J. (1998). *Principal instructional leadership. Advances in educational leadership.* Greenwich, CT: Jai Press.

National Assessment of Educational Progress (NAEP). (2011). *Trends in academic progress* (NCES 2009–479). Washington, DC: National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education.

National Governors Association Center for Best Practices & Council of Chief State School Officers. (2010). *Common core state standards*. Washington, DC: Author.

National Science Board (NSB). (2010). *Science and engineering indicators 2010*. Arlington, VA: National Science Foundation.

National Science Foundation (NSF). (2006). *America's pressing challenge—Building a stronger foundation*. Arlington, VA: Author.

National Science Teachers Association (NSTA). (2007). *NSTA position statement: Induction programs for the support and development of beginning teachers of science*. Retrieved from http://www.nsta.org/about/positions/induction.aspx

Neal, H. A., Smith, T. L., & McCormick, J. B. (2008). *Beyond sputnik: US science policy in the twenty-first century*. Ann Arbor, MI: University of Michigan Press.

O'Donnell, R. J., & White, G. P. (2005). Within the accountability era: Principals' instructional leadership behaviors and student achievement. *NASSP Bulletin, 89*(645), 56–71.

Piaget, J. (1980). The psychogenesis of knowledge and its epistemological significance. In M. Piattelli-Palmarini (Ed.), *Language and learning: The Debate between Jean Piaget and Noam Chomsky* (pp. 23-54). Cambridge, MA: Harvard University Press.

Pintrich, P. R., & Schunk, D. H. (2001). *Motivation in education: Theory, research and applications*. Upper Saddle River, NJ: Prentice Hall Merrill.

Posnanski, T. J. (2002). Professional development programs for elementary science teachers: An analysis of teacher self-efficacy beliefs and a professional development model. *Journal of Science Teacher Education, 13*(3), 189–220.

Program for International Student Assessment (PISA). (2012). *Results: Overcoming social background—equity in learning opportunities and outcomes* (Vol. 1). Paris, France: OECD.

Ramey-Gassert, L., Shroyer, M. G., & Staver, J. R. (1996). A qualitative study of factors influencing science teaching self-efficacy of elementary level teachers. *Science Education, 80*(3), 283–315.

Redmond, B. F. (2010). Self-efficacy theory: Do I think that I can succeed in my work? *Work Attitudes and Motivation*. University Park, State College, PA: The Pennsylvania State University.

Rice, D. C. (2005). I didn't know oxygen could boil! What pre-service and in-service elementary teachers' answers to 'simple' science questions reveals about their subject matter knowledge. *International Journal of Science Education, 27*, 1059–1082.

Riggs, I. M., & Enochs, L. G. (2006). Toward the development of an elementary teacher's science teaching efficacy belief instrument. *Science Education, 74*(6), 625–637.

Ross, J. (1994). The impact of an inservice to promote cooperative learning on the stability of teacher efficacy. *Teaching and Teacher Education, 10*(4), 381–394.

Ross, J., & Bruce, C. (2007). Professional development effects on teacher efficacy: Results of randomized field trial. *The Journal of Educational Research, 101*(1), 50–60.

Ross, J. A., & Gray, P. (2007) Transformational leadership and teacher commitment to organizational values: The mediating effects of collective teacher efficacy. *School Effectiveness and School Improvement, 17*(2), 179–199.

Saldaña, J. (2013). *The coding manual for qualitative researchers*. Thousand Oaks, CA: Sage.

Schunk, D. H. (1985). Participation in goal setting: Effects on self-efficacy and skills of learning disabled children. *Journal of Special Education, 19*, 307–317.

Sebring, P. B., & Bryk, A. S. (2000). School leadership and the bottom line in Chicago. *Phi Delta Kappan, 81*(6), 440–443.

Settlage, J., Southerland, S. A., Smith, L. K., & Ceglie, R. (2009). Constructing a doubt-free teaching self: Self-efficacy, teacher identity, and science instruction within diverse settings. *Journal of Research in Science Teaching, 46*(1), 102–125.

Shields, P. M., Marsh, J. A., & Adelman, N. E. (1998). *Evaluation of NSF's Statewide Systemic Initiatives Program: The SSIs impact on classroom practice*. Menlo Park, CA: SRI.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4–14.

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review*, *57*(1), 1–23.

Shymansky, J. A., & Kyle, W. C. (1992). Establishing a research agenda: Critical issues of science curriculum reform. *Journal of Research in Science Teaching*, *29*(8), 749–778.

Southerland, S. A. (2013). Is it possible to teach "Science for All" in a climate of accountability? In J. A. Bianchini, V. L. Akerson, A. Calabrese Barton, O. Lee, & A. J. Rodriguez (Eds.), *Moving the Equity Agenda Forward:* Equity research, practice, and policy in science education (pp. 21–37). New York, NY: Springer.

Spillane, J. P., Halverson, R., & Diamond, J. B. (2004). Towards a theory of leadership practice: A distributed perspective. *Journal of curriculum studies*, *36*(1), 3–34.

Supovitz, J. A., & Turner, H. M. (2000). The effects of professional development on science teaching practices and classroom culture. *Journal of research in science teaching*, *37*(9), 963–980.

Symcox, L., & Benken, B. (2012). *Raising the bar for STEM education in California: Preparing elementary teachers in a model, scalable, STEM-rich clinical setting.* Grant Proposal to the S. D. Bechtel, Jr. Foundation. California State University, Long Beach.

Trends in International Mathematics and Science Study (TIMSS). (2007). *International science report: Findings from IEA's Trends in International Mathematics and Science Study at the Eighth and Fourth Grades*. Chestnut Hill, MA: Boston College.

Tschannen-Moran, M., & Hoy, A. W. (2007). The differential antecedents of self-efficacy beliefs of novice and experienced teachers. *Teaching and Teacher Education, 23*(6), 944–956.

Tschannen-Moran, M., Hoy, A. W., & Hoy, W. K. (1998). Teacher efficacy: Its meaning and measure. *Review of educational research*, *68*(2), 202–248.

Tschannen-Moran, M., & McMaster, P. (2009). Sources of self-efficacy: Four professional development formats and their relationship to self-efficacy and implementation of a new teaching strategy. *The Elementary School Journal*, *110*(2), 228–245.

Van Breukelen, G. J. (2006). ANCOVA versus change from baseline had more power in randomized studies and more bias in nonrandomization studies. *Journal of clinical epidemiology, 59*(9), 920–925.

Vygotsky, L. S. (1986). *Thought and language* (Rev. ed.). Cambridge, MA: MIT Press.

Wahlstrom, K. L., Louis, K., Leithwood, K., & Anderson, S. E.(2010). *Learning from leadership: Investigating the links to improved student learning*. Retrieved from ERIC database. (ED519152)

Watters, J. J., Ginns, I. S., Enochs, L., & Asoko, H. (1995, November). Science teaching self-efficacy of preservice primary teachers: A review of research in three countries. Paper presented at the Annual Meeting of the Australian Association for Research in Education, Hobart, Tasmania.

Wee, B., Shepardson, D., Fast, J., & Harbor, J. (2007). Teaching and learning about inquiry: Insights and challenges in professional development. *Journal of Science Teacher Education*, *18*(1), 63–89.

The White House. (n.d.). *Reforming No Child Left Behind*. Elementary and Secondary Education Act [Press release]. Retrieved from http://www.whitehouse.gov/issues/education/k-12/reforming-no-child-left-behind

The White House, Office of the Press Secretary. (2010, March). *Obama Administration sent to Congress a blueprint for reform of the Elementary and Secondary Education Act*. Washington, DC: The White House. Retrieved May 18, 2014, from https://www.whitehouse.gov/issues/education/k-12/reforming-no-child-left-behind

Wholey, J. S., Hatry, H. P., & Newcomer, K. E. (2010). *Handbook of practical program evaluation* (3rd ed.). San Francisco, CA: Jossey-Bass.

Wilson, S. M., Floden, R., & Ferrini-Mundy, J. (2001). *Teacher preparation research: Current knowledge, gaps, and recommendations*. Seattle, WA: Center for the Study of Teaching and Policy, University of Washington. Retrieved from https://depts .washington.edu/ctpmail/PDFs/TeacherPrep-WFFM-02-2001.pdf

Wingfield, M. E., Freeman, L., & Ramsey, J. (2000). *Science teaching self-efficacy of first year elementary teachers trained in a site based program*. Retrieved from ERIC database. (ED439956)

Yockey, R. (2011). *SPSS demystified: A step-by-step guide to successful data analysis* (2nd ed.). Boston, MA: Prentice Hall.