

A CASE STUDY OF NOVICE TEACHERS' MATHEMATICS PROBLEM SOLVING
BELIEFS AND PERCEPTIONS

by

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Dedication

This is dedicated to my loving husband, Todd, my two wonderful daughters Kerrington and Cora, and my parents, Jeffrey and Shelley Hilber.

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Table of Contents

	Page
List of Tables	viii
List of Abbreviations	ix
Abstract.....	x
Chapter One	1
Significance.....	5
Research Questions	9
Definitions.....	9
Problem solving.	9
Beliefs.	10
Novice teachers.....	10
Chapter Two	11
Introduction.....	12
Pre-service Teachers	13
Perceptions of problem solving and mathematics.	13
Perceptions of non-routine problems.	16
Pre-service teachers as problem solvers.	20
The Mathematics Methods Course	23
A constructivist approach.	23
The instructor’s point of view.....	25
Fostering positive attitudes.	27
Addressing mathematics anxiety.	28
Academic backgrounds and mathematics anxiety.	32
Beliefs	34
Changing pre-service teachers’ beliefs.	34
Inconsistencies.	41
Changing in-service teacher beliefs through professional development.	42
Teach for America	46
Perceptions.....	48
Improving the model.....	49
Effectiveness.....	49
The Common Core State Standards for Mathematics.....	51
The standards for mathematical practice.	52
Perceived needs.....	53

Conclusions	54
Chapter Three	58
A Qualitative Case Study	58
Evolving Research Questions	59
The Identification and Selection of Participants	60
Participant demographics	62
Teach for America.	63
The elementary mathematics methods course.	64
Data Sources	64
Interviews	65
Other data sources	66
Good mathematics problems questionnaire.	66
Mathematics problems	67
Beliefs survey	68
Procedures	68
Data Analysis	69
Validity	73
Limitations	75
Boundaries	76
Chapter Four	77
Academic and Personal Backgrounds	78
Anxiety in school.	79
Elizabeth: Anxiety relieved by sacrificing time	79
Kerri: Anxiety relieved by conceptual understanding.	81
TFA as an entry into teaching.	84
Elizabeth: Buying herself time	84
Kerri: A means to an end.	85
The Elementary Mathematics Methods Course	86
Elizabeth: It's not where I am.	87
Kerri: A reluctant buy-in to problem solving.	89
The Influence of the CCSSM	91
Elizabeth: A focus on content.	92
Problem solving as differentiation.	96
Perceptions of good problems	100
Kerri: A focus on process.	100
Problem solving for all	106
Perceptions of good problems	108
District assessments and the CCSSM.	109
Elizabeth: Assessment drives instruction	109
Kerri: A necessary evil	110
Beliefs in Impacting Students	111
Elizabeth: Impacting students I can reach.	112
Kerri: Impacting all	114

Longevity In Teaching.....	115
Elizabeth.....	115
Kerri.....	117
Conclusions.....	117
Chapter Five.....	119
Research Question 1	120
Research Question 2	121
Research Question 3	122
Implications for Research and Mathematics Teacher Education.....	125
Implications of research.....	126
Problem solving and teacher evaluations.....	126
Perceived longevity of teacher candidates.....	127
Transitioning into the classroom.....	128
Implications for mathematics teacher education.....	129
Continued exposure to problem solving and non-routine problems.....	129
Purposeful planning of the standards for mathematical practice.....	131
Problem solving as an introduction.....	132
The need for more than one methods course.....	132
Professional development on the CCSSM.....	133
Alignment of professional development.....	134
Closing Thoughts.....	135
APPENDICES	137
Appendix A: Interview #1 Protocol.....	138
Appendix B: Interview #2 Protocol.....	139
Appendix C: Interview #3 Protocol.....	141
Appendix D: Good Mathematics Problems Questionnaire	142
Appendix E: Lion Cub Problem	151
Appendix F: Rabbit Problem	152
Appendix G: Beliefs Survey	153
Appendix H: Human Studies Review Board Approval	156
Appendix I: Instructor Protocol	157
References.....	159

List of Tables

Table	Page
Comparison of Influence on Problem Solving Beliefs and Perceptions by Participant ...	77

List of Abbreviations

CCSSM	Common Core State Standards for Mathematics
CCSSO	Council of the Chief State School Officers
GMPQ	Good Mathematics Problems Questionnaire
LMT	Learning Mathematics for Teaching
MARS	Mathematics Anxiety Rating Scale
MARS-R	Mathematics Anxiety Rating Scale - Revised
MTEBI	Mathematics Teaching Efficacy Beliefs Instrument
NCTM	National Council of Teachers of Mathematics
NGACBP	National Governors Association Center for Best Practice
PDS	Professional Development School
TFA	Teach for America

Abstract

A CASE STUDY OF NOVICE TEACHERS' MATHEMATICS PROBLEM SOLVING BELIEFS AND PERCEPTIONS

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The problem solving standards of the Common Core State Standards for Mathematics (CCSSM) (NGACBP & CCSSO, 2010) and the National Council of Teachers of Mathematics (NCTM) (2000) are at times foreign to pre-service teachers who previously experienced algorithm-emphasized instruction. Once in their own classrooms, these individuals face an ongoing struggle between implementing what they have learned and resorting to their past experiences. The purpose of this study was to explore the problem solving beliefs and perceptions of two novice teachers, Elizabeth and Kerri, in a TFA cohort. A descriptive case study approach is used to identify the influences of academic and personal backgrounds, the elementary mathematics methods course, and the CCSSM on their beliefs and perceptions of problem solving. Findings indicate that previous experiences shaped many of Elizabeth and Kerri's problem solving beliefs and perceptions. However, the way each interpreted the CCSSM greatly influenced the

manner in which they perceived their ability to incorporate problem solving into their instruction. Additionally, the use of purposeful planning of the standards of mathematical practice (NGACBP & CCSSO, 2010) influenced the perceived success of teaching elementary mathematics through problem solving. In light of these findings, implications include the need to align the content of elementary mathematics methods courses with professional development opportunities offered for in-service teachers.

Chapter One

One of the greatest influences on problem solving in mathematics was Polya's classic, *How To Solve It* (Lesh & Zawojewski, 2007). Providing a rich description of problem solving heuristics, Polya (1945) intended his book to create both motivation and interest of students and teachers alike. His purpose was to break down barriers that inhibited problem solving such as not fully understanding the problem, a lack of patience, the inability to identify what didn't work, and the determination of an appropriate strategy. Through the use of devising, implementing and reflecting on a plan to understand the problem, Polya wanted to provide guidance for teachers with questioning in order to appropriately challenge the student:

A teacher of mathematics has a great opportunity. If he fills his allotted time with drilling his students in routine operations he kills their interest, hampers their intellectual development and misuses opportunity. But if he challenges the curiosity of his students by setting them problems proportionate to their knowledge, and helps them to solve their problems with stimulating questions, he may give them a taste for, and some means of independent thinking (Polya, 1945, p. v).

Polya envisioned students and teachers equally sharing responsibility in the problem solving experience, utilizing multiple approaches and developing comprehension of the involved mathematics.

However, much of the research that followed Polya placed an emphasis on problem solving as a process (Lesh & Zawojewski, 2007). Polya's message of the intricacy of problem solving was lost as his heuristics became an oversimplified set of steps. The result was found to inhibit student success (Schoenfeld, 1992). Problem solving was either taught as an instructional unit, or after the students mastered identified mathematical concepts. These practices continued the strong and often negative beliefs that getting an answer to a mathematical problem involved remembering and applying rules that the teacher must confirm (Lampert, 1990; Lesh & Zawojewski, 2007). Students often perceived that problem solving was a quick activity for individuals who were experts at mathematics and as a result, developed little to no understanding and failed to make connections to the real world (Lampert, 1990).

The result of teaching problem solving as a process has also promoted a disconnect between the mathematical application of the academic and professional worlds. The focus on basic skills and procedures has caused students to be unprepared for high-paying jobs that required higher-level mathematical thinking (Gainsburg, 2003; Hall, 1999). During a time in which many of the high-paying jobs required individuals to possess 21st century skills such as critical thinking, producing students who focused on basic skills provided unqualified individuals to the workforce.

In order to stay true to Polya's vision of problem solving, problem solving needed

to step away from something that was done and move towards something that was explored. An alternative was needed to treating problem solving as an entity in itself while promoting problem solving within the contextual learning of mathematics (Lesh & Zawojewski, 2007). The incorporation of standards promoted by the National Council of Teachers of Mathematics (NCTM, 2000) described problem solving as an essential aspect of learning mathematics. The NCTM embraced Polya's beliefs that problem solving should be incorporated throughout the mathematics curriculum instead of being taught in isolation. The NCTM (2000) defined problem solving as:

Engaging in a task for which the solution method is not known in advance. In order to find a solution students must draw on their knowledge, and through this process, they will often develop new mathematical understandings. Solving problems is not only a goal of mathematics but also a major means of doing so (p.52).

Multiple curricula were designed to teach mathematics through the NCTM (2000) process standards, specifically problem solving (Senk & Thompson, 2003). However, due to constant paradigm shifts, teacher training, previous mathematical beliefs and understandings and the incorporation of high-stakes testing, these curricula were often put aside in favor of more skill-based, traditional approaches.

Despite the implementation of national standards, the lack of problem solving and mathematical understanding that students in the United States (U.S.) possessed was highlighted in the 2007 Trends in International Mathematics and Science Study (TIMSS) (Mullis, Martin, & Foy, 2008). The results identified Singapore, a country whose

curriculum is centered on problem solving (Seng, 2000; WWC, 2009), as a world leader in mathematics achievement. The United States lagged behind not only Singapore, but other nations as well (Gonzales, et al., 2008). In the U.S., only 10% of students passed advanced, placing them at 9th among the 49 ranked countries. As a result of Singapore's international success in the 2007 TIMSS, many educators have recently begun to implement problem solving approaches, such as Singapore's, in hopes of greater mathematical student achievement (Ferrucci, Yeap, & Carter, 2003; Hazelton & Brearley, 2008).

In 2010, the Common Core State Standards for Mathematics (CCSSM) were introduced in the U.S. (NGACBP & CCSSO, 2010). The CCSSM provided a national mathematics curriculum in which mathematics standards were identified and encouraged a problem solving approach to teaching the standards in order to develop mathematically proficient students:

Mathematically proficient students start by explaining to themselves the meaning of a problem and looking for entry points to its solution...[They] check their answers to problems using a different method, and they continually ask themselves, "Does this make sense?" They can understand the approaches of others to solving complex problems and identify correspondences between different approaches (CCSSI, 2010, p. 9).

The CCSSM have not only complemented the standards set forth by the NCTM in 2000 but also aimed at improving the mathematics curriculum through the incorporation of problem solving (NGACBP & CCSSO, 2010).

Significance

Problem solving challenges many teachers as it “is a hallmark of mathematical activity and a major means of developing mathematical knowledge” (NCTM, 2000, p.116). Successful problem solving is difficult as it is continually embedded within the mathematics curriculum to allow students opportunity to solve problems in context (NGACBP & CCSSO, 2010; NCTM, 2000). Problem solving is an important aspect of elementary mathematics instruction in which “choosing problems wisely, and using and adapting problems from instructional materials, is a difficult part of teaching mathematics” (NCTM, 2000, p. 53). Teachers must understand that elementary mathematics is involved and not simple (Ellis, Contreras, & Martinez-Cruz, 2009; Lee & Kim, 2005; Patton, Fry, & Klages, 2008). Additionally, teachers should provide accessibility of the problem to their students by differentiating the problem via multiple entry points and specifically chosen manipulatives (Van de Walle, Karp, & Bay-Williams, 2010). In order for students to obtain these skills, teachers must provide them.

In the elementary mathematics methods course, pre-service teachers are presented with problem solving standards set by both the CCSSM (NGACBP & CCSSO, 2010) and the NCTM (2000). It is essential for pre-service teachers to develop an understanding of problem solving if they are to incorporate problem solving throughout the mathematics curriculum. In fact, research has shown incorporating specific instruction on problem solving can change pre-service teachers’ mathematical understanding (Barlow & Cates, 2006; Davis & McGowen, 2001). Although mathematics methods courses are designed to influence pre-service teachers’ understanding of elementary mathematics, the knowledge

pre-service teachers take away from mathematics methods courses and how they incorporate the material into their pre-existing beliefs can vary widely. Problem solving still poses a challenge for many novice teachers as the problem solving standards of the CCSSM (NGACBP & CCSSO, 2010) and the NCTM (2000) presented in the methods class are at times foreign and opposing to pre-service teachers previous beliefs.

If the teacher believes that mathematics involves one correct answer and one correct mathematical procedure per problem, chances are the instructional approach taken by that teacher will focus on the mathematical concepts and procedures being taught not on the process of discovering the answer(s) to the problem (Baker, 2004, p. 43).

While a goal for mathematics education is to include more interactive instruction and more complex problem solving for students (NGACBP & CCSSO, 2010), classroom instruction can differ due to the fact that new beliefs and ideas are not always accepted or sustained by teachers (Foss & Kleinsasser, 2001). The beliefs and experiences individuals bring with them as they enter the classroom for the first time are resilient and difficult to change, as many beliefs are formed through experience over an extended period of time (Foss & Kleinsasser, 2001; Guillaume & Kirtman, 2005; Hart, 2002). Additionally, old beliefs are not replaced with new ones. When faced with new ideas a delicate balance is created in which new ideas mesh with old (Ambrose, 2004; Hart, 2002; Scott, 2005; Warfield, Wood, & Lehman, 2005). Thus, teachers' preexisting beliefs and perceptions of problem solving have an impact on the manner in which they plan and implement instruction.

Changing the beliefs an individual possesses with regards to mathematics teaching and learning can be challenging. For elementary mathematics teachers, a major concern is that the problem solving standards of the CCSSM (NGACBP & CCSSO, 2010) or the NCTM (2000) are at times foreign to teachers whose past instructional experiences focused primarily on memorization and algorithms (Andrew, 2006; Phelps, 2007; Stuart & Thurlow, 2000). Once in their own classrooms, these individuals face an ongoing struggle between implementing the perceptions of what they have learned and resorting to their past beliefs and experiences. For this reason it is important for researchers to develop an understanding of how beliefs and backgrounds influence the problem solving beliefs and perceptions of novice teachers.

Due to the recent implementation of the CCSSM (NGACBP & CCSSO, 2010), little research was identified that discussed either the implementation or application of the mathematical standards and practices in an elementary setting. Previous research on changing problem solving practices in elementary mathematics has focused on either pre-service teachers enrolled in a mathematics methods course (Ambrose, 2004; Davis & McGowen, 2001; Ellis, Contreras, & Martinez-Cruz, 2009; Lee & Kim 2005) or in-service teachers participating in a professional development opportunity (Warfield, Wood, & Lehman, 2005). Previous research on teacher licensure routes has focused on identifying the differences in student achievement and teacher attrition. The researcher for this study was unable to identify any research on Teach for America (TFA) and the implementation of problem solving as a means to teach elementary mathematics.

One challenge to both the research and instructional implementation of problem solving has been the constant paradigm shift between basic skills and problem solving. As the pendulum has swung back and forth, the change of emphasis in mathematics from skills to application has resulted in little knowledge gained, as not enough time has been spent on any one emphasis (Lesh & Zawojewski, 2007). As a result, the amount of research in problem solving has been on the decline as witnessed by: (1) a decrease in journal articles and publications (Lester & Kehle, 2003; Stein, Boaler, & Silver, 2003); and (2) the emphasis in mathematics has been placed on high-stakes assessments that focus on the basic skills and getting the right answer, instead of the critical thinking and conceptualization of mathematics (Lesh & Zawojewski, 2007).

This study will provide both a unique perspective of the field of mathematics education in addition to filling a void in the literature by examining how the knowledge gained on problem solving in the mathematics methods course is applied during the first years of teaching. This study will explore the influence of beliefs and background on novice teachers' perceptions of problem solving. This study also has the potential to provide a start to the exploration of how the beliefs from a mathematics methods course are sustained or perceived. Additionally, this study has the potential to provide insight into novice teachers' beliefs and perceptions of implementing the CCSSM (NGACBP & CCSSO, 2010) standards in mathematics. In a time when both teacher education and teacher quality are closely scrutinized, identifying characteristics between the relationships of teachers' experiences in teacher preparation courses and their experience as K-12 mathematics learners need further investigation to provide insight into

opportunities and barriers for teacher professional development.

Research Questions

The purpose of this investigation, then, is to investigate the problem solving beliefs and perceptions of novice teachers employing the following research questions:

1. In what ways do personal and academic background influence the problem solving beliefs and perceptions of second-year teachers in a TFA cohort?
2. In what ways do the elementary mathematics methods course influence the problem solving beliefs and perceptions of second-year teachers in a TFA cohort?
3. In what ways do the implementation of the CCSSM influence the problem solving beliefs and perceptions of second-year teachers in a TFA cohort?

Definitions

Throughout this study several terms are used that are frequently internalized differently. To assist with clarification, the following definitions will be utilized for the duration of this study.

Problem solving. According to the NCTM (2000) problem solving is an essential aspect of learning mathematics and should be embedded into every aspect of the mathematics curriculum instead of being taught in isolation.

“Problem solving means engaging in a task for which the solution method is not known in advance. In order to find a solution students must draw on their knowledge, and through this process, they will often develop new mathematical understandings. Solving problems is not only a goal of mathematics but also a

major means of doing so” (NCTM, 2000, p.52).

Beliefs. In the *Second Handbook of Research on Mathematics Teaching and Learning*, Phillip (2007) provides detailed definitions of both beliefs and affect as many researchers use the two interchangeably and the distinctions are often confused. Philipp provides the following definition for beliefs in order to support individuals in better understanding the concept.

“Psychologically held understandings, premises or propositions about the world that are thought to be true. Beliefs are more cognitive, are felt less intensely, and are harder to change than attitudes. Beliefs might be thought as lenses that affect one’s view of some aspect of the world or as dispositions towards action”

(Philipp, 2007, p. 259).

Novice teachers. Since the Teach for America teachers are assigned a classroom of students for which they alone are responsible during the two years of their teacher certification program, these individuals may technically be considered first-year teachers. However, individuals in Teach for America are provisionally licensed and do not obtain their teaching license until the completion of their second year. For that reason, the definition of novice teachers in this study will encompass in-service teachers who have been assigned a classroom of elementary students for which they are independently responsible.

Chapter Two

Over the past six years I have identified an extensive collection of literature in the areas of problem solving and pre-service teachers. The compilation of these areas forms the foundation of this literature review and the basis of my research. More recently, I have run multiple searches in an attempt to identify all the current and relevant literature. An exhaustive search was conducted using the following databases: ERIC, Education Full Text, and Education Research Complete. The following key words were utilized during literature searches: problem solving, elementary mathematics, mathematics methods, mathematics anxiety, beliefs, professional development, pre-service teachers, novice teachers, provisionally licensed teachers, in-service teachers, Teach for America, teacher licensure, teacher certification and Common Core State Standards for Mathematics.

One of the greatest challenges I faced was the determination of where individuals from TFA fit into the literature. Although TFA teachers take an elementary mathematics course, they are not technically pre-service teachers at that time since they are the sole individuals responsible for teaching their students. However, they are not in-service teachers because they are still completing licensure requirements. When searching ‘problem solving’ and ‘elementary mathematics’ I tried the terms ‘provisionally licensed’, ‘provisional’ and ‘novice teachers.’ Unfortunately, no related articles were

identified. As a result, the literature in this review covers what I could identify for both pre- and in-service teachers. An emphasis is placed on pre-service teachers as: (1) I believed that TFA teachers were more like pre-service teachers with their lack of training; and (2) more research was available on pre-service teachers problem solving perceptions and beliefs.

Introduction

The adoption of the NCTM's Standards (2000) resulted in multiple adaptations to the teaching and learning of mathematics, including an emphasis on problem solving (Krulik & Rudnick, 1998). Previously, traditional textbooks viewed problem solving as an application of computation and operations (Kamii & Housman, 1993). With the incorporation of the NCTM Standards (2000), problem solving became "an integral part of all mathematics learning" (NCTM, 2000, p.52) in which mathematics content could be taught. Carefully chosen problems had the ability to encourage students' creativity. Problems created closely to students' lives could provide real-world examples to which they could relate. Multiple solutions had the potential to encourage discussions among students as they compared their answers to the process of obtaining the solutions (Kamii & Housman, 1993). Even students as young as kindergarteners possessed a natural ability to accurately solve problems and reflect upon their work (Outhred & Sardelich, 2005). Through the use of models and illustrations all students were capable of independently problem solving and developing a deep understanding of mathematics.

Despite the importance of utilizing problem solving to access the mathematics curriculum, the previous experiences of teachers, both pre-service and in-service, have

inhibited their ability to successfully incorporate problem solving as intended by both the CCSSM (NGACBP & CCSSO, 2010) and the NCTM (2000). The previous instruction for problem solving that they experienced often placed an emphasis on traditional algorithms and focused on determining an operation prior to understanding the problem. As a result the mathematics methods course has been a place that often introduces methods of problem solving that are unfamiliar and confusing. Many pre-service teachers already experience false perceptions towards mathematics; including an overconfidence in their problem solving ability (Patton, Fry, & Klages, 2008) and the notion that elementary mathematics is simple and not complex (Lee & Kim, 2005; Patton, Fry, & Klages, 2008).

Pre-service Teachers

A great amount of research has been conducted on pre-service teachers in the hopes of changing their beliefs to fit with the practices they are exposed to throughout their licensure programs. When it comes to elementary mathematics there are several factors that have been found to influence pre-service teachers. These factors include: (1) their perceptions of problem solving and mathematics; (2) their perceptions of non-routine problems; and (3) their ability to act as problem solvers.

Perceptions of problem solving and mathematics. If the purpose of the mathematics methods course was to influence pre-service teachers towards the ideas of the CCSSM (NGACBP & CCSSO, 2010) and the NCTM (2000), then understanding how pre-service teachers perceive problem solving has become an essential aspect of the teaching and learning of mathematics. At times pre-service teachers are over-confident

in their mathematical abilities (Patton, Fry, & Klages, 2008). Additionally, their perceptions of what makes both good problems (Lee & Kim, 2005) and problem solvers (Parks, 2004) can have a negative impact on their instruction.

Patton, Fry, and Klages (2008) studied the mathematics performance and confidence of a group of 24 pre-service teachers and 10 mathematics master's students enrolled at a Texas university. Participants were first asked to answer six open-ended questions that were aimed at better understanding the participants' confidence and skills. The participants then solved seven problems that were modeled after released questions from the Texas 4th grade standardized exams. While the findings indicated that all of the participants felt confident about doing the mathematics, the results provided a different story. The total scores of the participants' correct responses were between 42% and 98%. However, only between 26% and 71% of the correct responses utilized an appropriate strategy. The results of this research indicated differences between the perceptions and abilities of pre-service teachers. As a result, many of the individuals were incorrectly overconfident. This data supports the claim that many pre-service teachers feel it is easy to teach elementary mathematics. However, it also provided evidence for the need to identify and address the incorrect perceptions, beliefs and over-confidence of pre-service teachers hold during their mathematics methods courses.

In addition to addressing false perceptions of teaching mathematics, the mathematics methods course has also been a place in which the perceptions of problem solving were addressed. Lee and Kim (2005) recognized problem solving as an important goal that pre-service teachers should internalize prior to beginning their

teaching careers. However, the perception of what pre-service teachers actually take away from instruction widely varies. Twenty-two teacher candidates enrolled in a mathematics methods course at a southern teacher education institution completed surveys and were interviewed to determine their classification of problems. The findings indicated that non-routine problems were frequently rated lower than more traditional problems that involved algorithms. When asked to explain why they rated the non-routine problems lower, the pre-service teachers indicated that the non-routine problems were not straightforward, difficult to comprehend, more challenging and lacked a single answer. Their perceptions of teaching mathematics were that the content they were responsible for teaching should be simple and basic. Pre-service teachers need to be aware that the mathematics they will teach is complex. Even the youngest learners need to be exposed to rich non-routine problems that will lead to debates and discussions of the content.

Identifying what pre-service teachers do when they encounter problems that they perceive as challenging also has many implications for the teaching and learning of mathematics. In an attempt to identify some of these implications, Parks (2004) explored how two pre-service teachers adjusted a mathematics curriculum based on their perceptions of the involved tasks. Each of the pre-service teachers lightened the cognitive load of the curriculum by reducing both the length of the lesson and the independent work time. Findings indicated that the pre-service teachers felt that the students would not be able to handle the involved mathematics due to their attention span or perceived difficulty of the tasks. The implications of this study are that when faced with implementing rigorous and rich problems within the mathematics class, teachers may

inadvertently decrease the rigor by preventing students from struggling with the content to come to a better understanding. What the pre-service teachers in this study failed to realize was that allowing students to struggle with the mathematics content actually assisted students with coming to grips with their own mathematical understandings.

Overall, pre-service teachers have the tendency of being over-confident in their abilities (Patton, Fry, & Klages, 2008). Their beliefs and perceptions of what makes a good problem (Lee & Kim, 2005) and problem solvers (Parks, 2004) are often not aligned with the beliefs individuals need to possess to problem solve effectively (House, Wallace, & Johnson, 2013).

Perceptions of non-routine problems. Pre-service teachers often perceive non-routine problems as having less value than simpler, more traditional problems (Lee & Kim, 2005). This may be due to the fact that simpler problems appear more accessible to students. One part of that perception has most likely been developed from the pre-service teachers' lack of exposure to non-routine problems during their own backgrounds and school experiences. This lack of exposure is described by several researchers.

Crespo (2003) explored the change in pre-service teachers' choice of problems for students by their participation in a pen pal letter project. In the writing exchanges between fourth graders and 20 pre-service teachers, the pre-service teachers incorporated problems into their letters for their pen pals to solve. In the beginning, pre-service teachers were found to include problems that were either easy or familiar to the students and had not previously been solved by the participant. These problems were simple and more traditional in nature. However, towards the end of the project, many of the pre-

service teachers changed their approaches to utilize unfamiliar problems that challenged the thinking and learning of the involved students. Through the pen pal letters, journal reflections and a case report, the mathematics methods instructors involved were identified by the pre-service teachers as being supportive in their growth by introducing non-routine problems in the methods course and allowing peers to collaborate.

The incorporation of non-routine problems by mathematics methods instructors has played an important role in addressing pre-service teachers' perceptions of good problems. Ellis, Contreras and Martinez-Cruz (2009) provided a narrative reflection on the incorporation of a single non-routine problem in an elementary mathematics methods course. One non-routine problem was assigned to the pre-service teachers due to its complexity and engaging nature. As the pre-service teachers' interacted with the non-routine problem, the mathematics methods instructor engaged the pre-service teachers in a discussion, while a second mathematics methods instructor took notes of the process; paying specific attention to participants problem solving abilities and strategies. Pre-service teachers were asked to not only solve the problem, but also to describe, justify and extend the involved patterns. Despite the fact that the problem was thoroughly solved during just one class session, the problem was discussed and reflected upon throughout the remainder of the course. Recognizing that pre-service teachers may not have had previous experiences to think deeply about mathematics, Ellis, Contreras and Martinez-Cruz (2009) believed that non-routine problem solving was important and should be ongoing throughout the mathematics methods course. By exposing pre-service teachers to various types of problems during the mathematics methods course they will hopefully be

more likely to use rigorous and rich non-routine problems instead of problems that are simple and basic.

Finding similar results to Ellis, Contreras and Martinez-Cruz (2009), Asman and Markovits (2009) utilized both pre-service and in-service elementary teachers for their problem solving research. Focused on the abilities of 30 (10 pre-service and 20 in-service) teachers' solving of non-routine problems and the beliefs they possessed regarding their abilities, participant interviews consisted of both in-depth and open-ended questions in addition to 10 problems that the participants solved. After each problem was presented, participants were asked to explain their perceptions and beliefs regarding the problem. Findings indicated that both in-service and pre-service teachers felt challenged by the non-routine problems and had difficulty solving them. Overall, the teachers solved approximately half the problems accurately. Interestingly enough, approximately 85% of the teachers stated that although they had difficulty in solving the problems, they would give those exact problems to their students. One reason for this might be due to the fact that during the interviews the participants who did not reach a correct answer either went back and tried it again, or were guided to the correct answer by the interviewer. Some teachers mentioned that they would have exposed their students to non-routine problems, if this type of problem had appeared in the textbook. Since pre-service teachers are typically not exposed to non-routine problems prior to entering the mathematics methods course, providing them time for guidance and exploration is essential in developing their problem solving abilities.

Guberman and Leikin (2012) explored pre-service teacher perceptions of

multiple-solution tasks. Multiple-solution tasks were defined as those tasks that specifically required more than one solution. The research emphasized understanding the pre-service teachers' success with and the perceptions of the problems over the length of the course. Twenty-seven participants who had received their B.Ed. degree in elementary school mathematics were divided into three groups based on their scores from previous mathematics courses. The three groups were approximately equal in size. Problem solving competencies were apparent in both the high- and low-achieving groups. Throughout the course pre-service teachers became more successful with the tasks and exhibited an increase in the number of strategies used to solve the tasks. As a result, the pre-service teachers confidence in problem solving and teaching elementary mathematics increased. These findings indicate that problem solving instruction that incorporates multiple-solution tasks is beneficial for learners at all levels.

As a result of the research on pre-service teacher perceptions of non-routine problems, several themes emerge. The predominant theme is that pre-service teachers initially perceive that non-routine problems are inaccessible to students (Lee & Kim, 2005). However, research has found that with continued exposure to non-routine problems the beliefs and perceptions of pre-service teachers can change to value non-routine problems more (Asman & Markovits, 2009; Crespo, 2003; Ellis, Contreras, & Martinez-Cruz, 2009). Additionally it was found that all pre-service teachers benefited from exposure to non-routine problems (Guberman & Leikin, 2012).

Pre-service teachers as problem solvers. One of the greatest challenges both in-service and pre-service teachers face is becoming effective teachers of problem solving (House, Wallace, & Johnson, 2013). There are many aspects to consider when implementing problem solving as the primary goal of elementary mathematics. House et al. (2013) discussed in the importance of developing teachers who are able to teach problem solving successfully. Effective teachers of problem solving are able to adapt and scaffold problems to meet the needs of their learners. As a result, teachers need to be able to evaluate problems in terms of the content and accessibility and appropriateness for their students. Teachers must become good problem solvers in order to effectively facilitate problem solving (House et al., 2013; Wilburn, 1997). As a result, several studies have investigated pre-service teachers' abilities to problem solve.

Wilburne (1997) investigated the impact of teaching meta-cognitive strategies to pre-service teachers in order to address their mathematical problem solving abilities and attitudes. In this study, two mathematics methods instructors each taught an experimental mathematics methods course that incorporated a six-week instruction of meta-cognitive skills, and a control group in which no meta-cognitive skills were taught. A total of 97 students were involved. Thirteen problems were chosen for the four methods courses to explore. Data collection instruments for this study included: A pre- and post- test to determine the problem solving ability of the participants, the Fennema-Sherman Attitude Effectance Motivation in Mathematics Scale which measured the pre-service teachers' attitudes regarding problem solving and exit interviews with select students. While no significant differences were found to exist between the experimental and control groups,

a statistically significant improvement appeared between the pre- and post-problem solving achievement in both groups. This provided some evidence that addressing the lack of pre-service teacher's problem solving abilities within the mathematics methods course has the potential to change their attitudes and behaviors.

Although Koray, Presley, Koksall, and Ozdemir's study (2008) focused on science and not mathematics, the problem solving techniques they utilized in the science methods course also demonstrated the potential pre-service teachers had of developing a deeper understanding of the content through problem solving. During their study, the authors gave some pre-service teachers in Turkey the opportunity to not only explore and foster problem solving within a science methods class. The participants were divided into two groups: One group utilized problem-based learning and the other class relied on traditional instruction. To measure the abilities of the pre-service teachers' problem solving, 28-item problem solving skills inventory was developed and found to have a cronbach α reliability of 0.87. Additionally, 25 of the pre-service teachers participated in a semi-structured interview and completed an open-ended questionnaire that aimed at identifying opinions of problem-based learning from the experimental group. Pre-service teachers in the experimental group were found to have increased communication and collaboration skills as well as an increased understanding of the involved processes. The increased understanding led the pre-service teachers to grasp the content better, as opposed to simply memorizing facts or procedures.

Another study that placed an emphasis on problem solving and utilized a partner relationship to deeply explore problems involved 15 volunteers that enrolled in an

additional mathematics methods course (Ambrose, 2004). The researcher of this study utilized a combination of pre and post-interviews, surveys, documents from the mathematics methods courses and field notes. The findings indicated that the participants initially struggled with some of the problem solving activities. However, this struggle allowed the pre-service teachers to better understand the complexities of teaching mathematics. The success of this research was contributed to the intense experience of the additional course, coupled with reflection and practical experiences.

Xenofontos and Andrews (2012) explored the problem solving beliefs of individuals entering into their undergraduate primary teacher education programs. The study consisted of 27 undergraduates from two different countries: Cyprus and England. Individuals were interviewed the first week of their university courses, prior to any formal instruction on mathematics. The findings indicated student perspectives' were aligned with the type of instruction they experienced in their respective countries. For example, participants from Cyprus perceived that problem solving incorporated real-world tasks, were often verbal, and required multiple readings of the problem to fully understand the context. An expert problem solver was one who could interpret the problem quickly and come up with both an effective plan and strategy. In contrast, participants from England perceived that problem solving was introduced after a concept was taught and accessed through a sequence of steps. Expert problem solvers were thought to know the formulas and strategies the problem required.

Overall, pre-service teachers need to be exposed to problem solving within the mathematics methods course to change their beliefs (Ambrose, 2004; Koray et al., 2008;

Wilburne, 1997). Addressing the pre-service teachers' inability to think flexibly about problem solving has been found to foster a deeper understanding (Ambrose, 2004; Koray et al., 2008). Additionally, an individual's background plays an important role in forming beliefs and perceptions towards problem solving (Xenofontos & Andrews, 2012) If pre-service teachers are to utilize these practices with students once they are in classrooms of their own, the mathematics methods course is one of the places to explore this issue.

The Mathematics Methods Course

In addition to assisting pre-service teachers with developing a deeper understanding of the teaching and learning of mathematics, the mathematics methods course has the potential to influence pre-service teachers in several other ways. However, designing the course in a way that addresses problem solving in a constructivist approach can be challenging for pre-service teachers and instructors alike (Andrew, 2006; Olanoff, Kimani, & Masingila, 2009; Raymond & Santos, 1995). The mathematics methods course has also been a place that encourages positive attitudes (Alsup, 2003; Crespo, 2003; LoPresto & Drake, 2004, Phelps, 2007; Wilburne, 2006) and addresses the anxieties of pre-service teachers (Bursal & Paznokas, 2006; Gresham, 2007, 2008; Malinsky, Ross, Pannells, & McJunkin, 2006).

A constructivist approach. The mathematics methods course is often viewed as a platform for exposing pre-service teachers to problem solving as envisioned by both the CCSSM (NGACBP & CCSSO, 2010) and the NCTM (2000). As a result, pre-service teachers enrolled in mathematics methods courses are encouraged to take control of their learning and construct their own understanding of doing and teaching mathematics

(Raymond & Santos, 1995).

With the implementation of the 2000 NCTM standards, Raymond and Santos' (1995) research explored the re-thinking of a mathematics methods course that was designed to meet the NCTM (2000) content and process standards while utilizing a constructivist approach. Upon observing the participants in the class, the researchers noticed that the mathematics methods course was not going "smoothly." During the final class meeting, the researchers asked for volunteers from the two sections of the course to interview regarding their experiences in hopes of identifying reasons for the difficulties: Eight females volunteered. Three themes emerged from the findings: (1) the participants developed a deeper understanding of what it meant to know, learn and teach mathematics (2) the methods course challenged pre-existing beliefs and allowed opportunities for participants to approach problems in multiple ways; and 3) participants experienced a sense of disequilibrium as they made sense of the mathematical ideas presented to them. These three themes support the statement that while at times challenging for the pre-service teachers, the mathematics methods course can be influential in addressing the pre-existing perceptions and beliefs of pre-service teachers.

Although Raymond and Santos' (1995) research indicated that the sense of disequilibrium felt by the pre-service teachers assisted individuals with delving deeper into the mathematics content, not all pre-service teachers value a constructivist approach. Andrew (2006) looked into the reactions of 61 pre-service teachers enrolled in their final mathematics methods course at a university. Instruction for all three methods courses were presented in a constructivist manner and aligned with the NCTM standards (2000).

Two surveys were utilized to collect data in which some of the questions were designed on either a 5- or 10-point scale, while other questions were open-ended. Data collected was sorted into themes using the constant-comparative method. Findings indicated that the pre-service teachers felt that they were not being taught how to teach, needed more guidance and knowledge from the instructor, and that the pre-service teachers had more control than the professor at times. These feelings and beliefs influenced the pre-service teachers to feel that they were not learning to teach elementary mathematics effectively.

Overall, previous research identified challenges instructors face when teaching the elementary mathematics methods course in a constructivist manner (Raymond & Santos, 1995). Not only do pre-service teachers perceive that they are not being taught (Andrew, 2006), they are also uncomfortable while learning (Raymond & Santos, 1995). Despite the challenges, when pre-service teachers are taught using a constructivist approach, their perceptions and beliefs have been positively influenced (Raymond & Santos, 1995).

The instructor's point of view. Pre-service teachers are not the only individuals who struggle with the design of the mathematics methods course. At times the mathematics methods instructors have difficulty with providing high-quality instruction in a manner that mimics the national goals for teaching mathematics.

Olanoff, Kimani, and Masingila (2009), explored how a mathematics methods course could be taught via problem solving. While one of the researchers would teach a mathematics methods course, the other two researchers observed. Afterwards, the authors would collaborate and reflect on the experience before the remaining two instructors taught their own group of pre-service teachers later in the week. Despite the fact that

there was already a text assigned for the mathematics methods courses, the instructors found that they constantly had to rearrange and modify the tasks to meet their needs. They struggled with providing authentic tasks in which they could scaffold and support the learning of their pre-service teachers, while still maintaining a high-quality, rigorous atmosphere for problem solving. The authors also grappled with knowing when to continue allowing the pre-service teachers to struggle and when to move on. An implication of this research is that, to be successful with the teaching and learning of mathematics, instructors must have an extremely high level of understanding of problem solving, collaboration, facilitation, and content. Olanoff, Kimani, and Masingila (2009) hinted that while many mathematics methods courses aim at teaching the content through problem solving, the reality may differ.

As an educator of pre-service teachers Libeskind (2011) also struggled with the mathematics content covered in an elementary mathematics methods course. For him, it was a constant battle with covering the content in its entirety, or modeling the methods he desired of future teachers. As a result of his experiences Libeskind provided several suggestions for developing the teaching methods of pre-service teachers. These suggestions include: Challenging all students, encouraging multiple solutions, explaining the content in more than one way, providing a source of excitement for the students, and making connections between mathematics, the history of mathematics, and mathematicians. A major implication of this research is that developing and teaching a mathematics methods course is not a simple task and requires much attention and effort if it is to change the perceptions of pre-service teachers.

Overall, research indicated that instructors need high levels of understanding to successfully influence pre-service teachers (Libeskind, 2011; Olanoff, Kimani, & Masingila, 2009). However, even with high levels of understanding, influencing pre-service teachers positively is not always the reality (Libeskind, 2011; Olanoff et al., 2009).

Fostering positive attitudes. How individuals perceive their mathematical ability is likely to influence the manner in which they teach mathematics. For pre-service teachers the elementary mathematics methods course is a place to increase both their comfort and confidence with teaching elementary mathematics.

Phelps (2007) explored how six pre-service teachers perceived being “good” at mathematics through a series of interviews. The pre-service teachers’ responses included the following descriptions of what being “good” at mathematics looked like: A natural ability, performing well on exams, receiving good grades, being able to find the answer, and the amount of effort a student exerted. The implications for this research are that the way in which a pre-service teacher defines success in mathematics may inhibit their own success at teaching. The background of an individual may also play an integral role in developing a mathematical identity.

In order to prevent teachers from fostering or developing negative attitudes towards problem solving, Wilburne (2006) presented pre-service teachers with non-routine problems on a weekly basis. The pre-service teachers were expected to work intensively with the non-routine problems by solving them in multiple ways, and determining appropriate strategies. However, the most important aspect of exposing the

pre-service teachers to problem solving was the written reflections which allowed pre-service teachers the opportunity to develop a better understanding of the involved mathematical processes. The reflections typically illustrated an increase in confidence and comfort with solving non-routine problems.

Another researcher that explored increasing the confidence levels of pre-service teachers focused on the development of norms to guide class discussions (Alsup, 2004). Seven classroom rules were identified that were aimed at developing a deeper understanding of the mathematics. As a result of activities and discussions that followed the norms, both the pre-service teachers' communication and responsibility for their own learning increased. Alsup claimed that pre-service teachers in this course were better prepared to teach the NCTM (2000) standards as a result.

Research has identified that developing pre-service teachers' positive attitudes towards elementary mathematics is possible. Both problem solving experiences (Wilburne, 2006) and the use of discussions (Alsup, 2004) have shown an increase in the comfort and confidence pre-service teachers experience.

Addressing mathematics anxiety. A disproportionately large percentage of pre-service teachers experience significantly high levels of mathematics anxiety" (Gresham, 2007, p. 183). These feelings of angst and nervousness must be addressed in order for individuals to not only feel comfortable teaching mathematics, but also foster positive feelings of mathematics in students. Negative attitudes of mathematics are often found to be prevalent in individuals that hold the highest levels of mathematics anxiety (Gresham, 2008). For these reasons, it is important for the mathematics methods course also address

mathematics anxiety.

In a study conducted by Gresham (2007), the levels of mathematics anxiety were analyzed through use of the Mathematics Anxiety Rating Scale (MARS): A 98-question survey that allowed users to rate their anxieties towards mathematics in varying situations. In conjunction with the MARS pre- and post-assessments, informal assessments, field notes and audio recordings of interviews were also utilized. Over a period of four years, the responses of 246 elementary pre-service teachers enrolled in mathematics content methods courses were collected and analyzed. In the instances of each of the four mathematics content methods courses, the overall anxiety of the population of students decreased as the course progressed. The pre-service teachers cited the use of concrete manipulatives, the methodology of the course, and journal writing as major reasons for their mathematics anxiety reduction. As an additional result, the pre-service teachers also noted an increased understanding of the mathematics content.

In 2008, Gresham extended her previous research by closely examining the relationship between the mathematics anxieties of pre-service teachers and their mathematics teacher efficacy. Data from the MARS and the Mathematics Teaching Efficacy Beliefs Instrument (MTEBI), an assessment that evaluated pre-service teachers' beliefs of their teaching capabilities, were collected from 156 elementary pre-service teachers. Both the MARS and the MTEBI were given at the end of an elementary mathematics methods course. Furthermore, the 10 individuals with the highest mathematics anxiety and the 10 individuals with the lowest mathematics anxiety as identified by the MARS results were interviewed to gather additional supporting data.

Negative attitudes of mathematics were found to be prevalent in those participants that held the highest levels of mathematics anxiety (Gresham, 2008). These pre-service teachers described feelings of stress, worry, isolation, embarrassment and hatred as they described their past experiences and feelings towards mathematics. In comparison, the pre-service teachers who had low levels of mathematics anxiety expressed a love of and a passion for the teaching and learning of mathematics. These pre-service teachers also enjoyed mathematical challenges presented in class. Overall, 18 of the 20 pre-service teachers interviewed believed that they could successfully and effectively teach elementary mathematics after the completion of the semester- long course. Gresham (2008) identified an inverse relationship between mathematics anxiety and efficacy: the individuals that held higher levels of mathematics anxiety held lower levels of teacher efficacy and vice versa. Interestingly enough, the two individuals who were unsure of their ability to successfully and effectively teach elementary mathematics both held high levels of mathematics anxiety.

Malinsky, Ross, Pannells, and McJunkin (2006) delved into the issue of mathematics anxiety in pre-service teachers and utilized the Mathematics Anxiety Rating Scale – Revised (MARS-R). Based upon the original 98-question MARS, the battery of questions on the MARS-R was limited to 24 and offered a more concise assessment. In addition to completion of the MARS-R, pre-service teachers were asked to respond either *true* or *false* to 12 myths that pertained to the field of mathematics. Both the MARS-R and myths were given to 481 students, 279 of which were pre-service teachers for elementary education. The remaining students were enrolled in coursework in the fields

of either mathematics or science. Findings indicated that the participants' mathematics anxiety increased as the content became more difficult. Additionally, pre-service teachers enrolled in non-mathematics concentrations, such as social studies or language arts, were more likely to possess feelings of fear or anxiety with regards to mathematics. These findings are of particular interest as many individuals from non-mathematics backgrounds enter into the profession of elementary education. In order to address the fears and anxieties they possess the mathematics methods course must pay specific attention to these issues.

Bursal and Paznokas (2006) also compared mathematical anxiety levels of pre-service teachers with their confidence level of teaching mathematics. Each of the 65 participants were enrolled in an elementary mathematics methods course in addition to two other methodology courses. At the conclusion of their coursework, the pre-service teachers were given three surveys that determined their anxiety levels in mathematics as well as their teacher efficacy beliefs in both mathematics and science. The result of this study concluded that the pre-service teachers possessed a lack of confidence in their abilities to teach mathematics and science which was directly related to the mathematic anxiety felt by the participants.

Sloan (2010) explored the mathematics anxiety levels of pre-service teachers in a standards-based mathematics method course. The participants were 72 pre-service teachers from three sections of an undergraduate elementary mathematics methods course that took the MARS. Twelve participants were selected for interviews aimed at exploring the origins of their anxiety, as well as aspects of the elementary mathematics methods

course that alleviated their anxiety. The results indicated that at the end of the semester anxiety levels were significantly reduced from their initial levels. The aspects of the course that helped to alleviate anxiety were: the methodology used by the instructor, the field experience and peer teaching, the classroom atmosphere and the instructor's disposition.

Academic backgrounds and mathematics anxiety. Understanding where mathematics anxiety stems from is essential if both pre-service teachers and their elementary mathematics methods are to address it. Several research studies have looked into the backgrounds of pre-service teachers to assist in identifying the origin of mathematics anxiety.

Bekdemir (2010) found that mathematics anxiety was present in numerous elementary school teachers, and as a result elementary pre-service teachers. The majority of mathematics anxiety stemmed from the participants' experiences learning mathematics as children. Specifically, the mathematics anxiety was the result of their teachers' behaviors and approaches when teaching mathematics. Sloan (2010) determined that the origins of math anxiety included: parents, negative school experiences, methodology of former teachers, low math achievement, test anxiety, lack of confidence, negative attitudes, mathematics avoidance, and mathematics background.

Trujillo and Hadfield (1999) explored the roots of mathematics anxiety in pre-service elementary teachers. In this study the MARS-R was utilized with 49 participants. Additionally, 5 out of the 49 pre-service teachers participated in interviews. Three commonalities were found among the individuals: (1) all of the participants had negative

experiences in the mathematics classroom; (2) none of them had much positive support from home; and (3) all of them suffered from mathematics anxiety.

One way to assist pre-service teachers with understanding the impact that their backgrounds play on their mathematics instruction is to have them write a mathematics autobiography (Crespo, 2003; LoPresto & Drake, 2004). Crespo (2003) found that mathematics autobiographies played an important role in recognizing which pre-service teachers were not confident and felt unsuccessful in mathematics. Forcing the pre-service teachers to evaluate their mathematics life story provided the mathematics methods instructor and pre-service teachers with not only the opportunity to better understand the pre-service teachers' values and beliefs, but also provided a platform from which the pre-service teachers were able to build positive future experiences. A second way to assist pre-service teachers with understanding the impact their mathematics anxiety plays on their mathematics instruction was identified by Peker (2009). In his research, Peker identified problem specific instruction on problem solving strategies as a way to reduce mathematics anxiety in elementary school teachers.

Many pre-service teachers have math anxiety (Bekdemir, 2010; Bursal & Paznokas, 2006; Gresham 2007, 2008; Malinsky, et al., 2006; Sloan 2010; Trujillo & Hadfield, 1999). Much of the anxiety stems from either previous experiences learning mathematics (Bekdemir, 2010; Sloan 2010; Trujillo & Hadfield, 1999) or at home from families (Sloan 2010; Trujillo & Hadfield, 1999). Individuals who have mathematics anxiety also possess a lack of confidence with regards to mathematics (Bursal & Paznokas, 2006; Gresham 2008; Sloan 2010). Their anxiety towards teaching

mathematics needs to be addressed prior to entering the elementary classroom. Previous research has identified two ways to reduce mathematics anxiety in pre-service teachers: 1) the use of mathematics autobiographies (Crespo, 2003; LoPresto & Drake, 2004); and 2) problem solving within the elementary mathematics methods course (Peker, 2009).

Beliefs

Identifying previous research on beliefs was essential in guiding this study. Multiple areas within the broad category of beliefs were researched. These areas of research include: (1) changing pre-service teacher's beliefs through the elementary mathematics methods course; and (2) changing in-service teacher beliefs through professional development.

Changing pre-service teachers' beliefs. Pre-service teachers' pre-existing beliefs are difficult to change (Rolka, Rosken, & Liljedhal, 2009). Not only are old beliefs resilient, but old beliefs are not simply replaced by the new ones (Ambrose, 2004). Often, new beliefs are something that pre-service teachers grapple with. Some research has attempted to identify how pre-service teachers' beliefs changed with the specific implementation of particular ideas (Davis & McGowen, 2001; Emenaker, 1996; Furner, 1995).

In a recent study (Scott, 2005) conducted in Australia, surveys and audio interviews were utilized to determine pre-service teachers' perceptions of teaching numeracy. Comparisons were made between a group of 163 pre-service teachers just beginning their coursework in elementary education and a group of 186 pre-service teachers preparing to graduate and enter the teaching profession. Questions pertaining to

both personal experiences and intentions for incorporating particular methods into practice allowed researchers to observe the influences of pre-service teachers' beliefs on their intentions for teaching. Many of the participants recalled their own learning of mathematics filled with direct instruction and independent seatwork. However, while their own experiences may not have involved either discussions or manipulatives, the pre-service teachers who had completed the required coursework truly believed that that these practices were important to include. The data also provided evidence that the pre-service teachers preparing to graduate from their studies greatly valued building upon student background knowledge and planned to incorporate it into their instruction. This instance illustrated the fact that the more recent experiences and observations provided in mathematics methods course were able to influence the belief systems of pre-service teachers.

In an attempt to quantify the change that pre-service teachers' beliefs undergo during the mathematics methods course, Hart (2002) developed an alternate model of the traditional mathematics methods course that promoted the Model/Experience/Reflect framework. In this model, constructivist methods were modeled and consistently observed. After receiving a firsthand learning experience that promoted a constructivist approach, the pre-service teachers reflected with both the mathematics methods course instructor and the classroom teacher. To determine the relationship between the participants' beliefs regarding mathematics and the consistency of their beliefs with the NCTM standards (2000), the MBI was administered to 14 pre-service teachers during their program orientation, and then again at the end of their student teaching experience.

The results indicated that the beliefs of the participants were more consistent with the NCTM standards after participating in the mathematics methods course.

Rolka, Rosken and Liljedhal (2009) also found that the beliefs of pre-service teachers changed after the presentation of material in the mathematics methods course. The course was designed with problem solving as a focus. Reflective journals from 39 students were evaluated for the identification of the pre-service teachers' on aspects of mathematical beliefs that ranged from traditional to constructivist. The results indicated that the constructivist viewpoint, was non-existent in the beginning of the methods course and emerged at the end. The results implied that the changing of beliefs was complex. Many individuals did not simply change their beliefs. Instead they added, discarded, or replaced aspects of previously held beliefs.

Furner's (2000) dissertation proposal study explored the impact of a secondary mathematics methods course on pre-service teachers' beliefs regarding the NCTM (2000) standards. This research utilized both the Standards Belief Instrument (SBI), which served as a pre- and post-assessment, as well as four open-ended questions. Twenty-five pre-service teachers enrolled in a secondary mathematics methods course were asked to describe their relationship with and background knowledge of the NCTM Standards. A paired sample t-test indicated that the secondary course in question had a statistically significant impact on the participants' beliefs with regards to the NCTM standards, $t(24) = 4.30, p < .0002$.

While the research of Furner (2000) looked into the impact of the NCTM standards (2000) on pre-service teachers' beliefs, Davis and McGowen (2001) attempted

to identify if non-routine problems utilized in the elementary math methods course impacted the long-term beliefs of pre-service teachers. During the mathematics methods course open-ended problems were collaboratively solved and independently reflected on by the pre-service teachers. Initially Jennifer, a student in the mathematics methods course, was unable to make connections between problems and struggled with wanting a formula to get at the correct answer. However, by the end of the course, Jennifer's understanding of mathematics drastically changed. She better understood and was more readily able to see the relationships between problems. Both the findings of Davis and McGowen (2001) and Furner (2000) indicated that specific instruction on problem solving within the mathematics methods course can change pre-service teachers' understanding of and comfort with mathematics.

A third study (Emenaker, 1996) was conducted in Indiana to determine the impact a mathematics methods course had on changing pre-service teachers' beliefs to meet the NCTM standards (2000). A Likert-style survey was designed and administered to five cohorts in order to determine the effects on the participants' beliefs. The survey consisted of 30 questions in which the participants needed to determine if they agreed or disagreed with the statement, and several open-ended questions that related to the usefulness of the involved mathematics. In addition to the survey, follow-up interviews were conducted with nine of the participants. The findings of this research indicated that introducing a problem-solving approach to teaching mathematics had a positive influence on the mathematical beliefs of the group as a whole. Additionally, higher-achieving pre-service teachers were impacted greater than lower-achieving pre-service teachers. Aspects of the

methods course that were perceived as influential in changing beliefs by the participants were the group work and regular solving of problems that conflicted with existing beliefs.

Swars, Hart, Smith, Smith and Tolar (2007) examined not only how pre-service teachers' mathematics pedagogical beliefs and teaching efficacy beliefs changed during a teacher preparation program, but also the relationship between the pre-service teachers' beliefs and specialized content knowledge. Data was collected from five cohorts of pre-service teachers ($n = 103$) that were enrolled in a large university in the southeastern United States. The MBI and the MTEBI were administered to measure the participants' beliefs regarding the reaching and learning of mathematics. At the end of the participants' student teaching experience, the Learning Mathematics for Teaching Instrument (LMT) was administered in order to measure the participants' specialized content knowledge for teaching mathematics. Overall, the participants developed a reform perspective in their teaching program. Beliefs were found to change the most during their coursework, and were maintained during field experiences. Throughout the two years the participants experienced an increase in efficacy with regards to the teaching and learning of mathematics. Additionally, individuals who had greater amounts of specialized mathematics content knowledge were more likely to hold a constructivist view of learning mathematics. These findings indicate that elementary mathematics methods courses can have a positive impact on the beliefs and efficacy of pre-service teachers.

Swars, Smith, Smith, & Hart (2009) examined both the changes of and relationships between pedagogical beliefs, teaching efficacy beliefs, anxiety and specialized mathematics knowledge in pre-service teachers allowed the researchers to

identify the success of their elementary mathematics methods courses. Data was collected from one cohort of pre-service teachers ($n = 24$) that were enrolled in a large university in the southeastern United States. A “quantitative-dominant” approach was taken that utilized four instruments. Two instruments were administered to the participants four times over the two-year certification process that measured the participants’ beliefs regarding the teaching and learning of mathematics: the MBI and the MTEBI. The MARS was administered three times to determine the levels of anxiety that the pre-service teachers were experiencing. At the end of the participants’ student teaching experience, the LMT was administered in order to measure the participants’ specialized content knowledge for teaching mathematics. Follow-up interviews were conducted after the second mathematics methods course. The results indicated that during the first course participants’ beliefs changed the most, followed by a slight decrease during the second course, and a significant decrease during student teaching. The researchers surmised that while the mathematics content was not challenging during the first course, the understanding of the teaching of mathematics was new and unfamiliar causing low levels of anxiety, and high levels of teaching beliefs.

Wilkins and Brand’s (2004) research looked at how the design of a mathematics methods course could develop an investigative approach that promoted understanding of both the content and pedagogy aligned with the NCTM’s vision. A 30-question survey was compiled from several researchers and given to 89 pre-service teachers. The results of the study suggested that not only did pre-service teachers’ beliefs change to become more aligned with the current mathematics education reform; their beliefs also positively

changed their self-efficacy.

Ninety-three pre-service teachers enrolled in three sections of a mathematics methods courses were the participants in Szydlik, Szydlik, and Benson's study (2003). In each of the three courses the mathematics methods instructor acted as a facilitator and guided discussions while the pre-service teachers solved a problem during the first 20-30 minutes of class. Specific norms were developed for both the running of the class, and the solving of the problems. The norms promoted an informal, respectful classroom that was run by the students, guided by the teacher, and promoted the pre-service teachers' ability to collaborate to solve the weekly problems. Each of the participants completed a ten-item questionnaire on the first day of class. Cumulative scores were assigned based on responses. Twenty-two students from each the upper-quartile, middle half, and lower-quartile were randomly selected for interviews. Six students were classified as holding non-autonomous beliefs, ten students as having mixed beliefs and six as having primarily autonomous beliefs. Five students changed beliefs from the survey to the interview. Each one held more autonomous beliefs than at the beginning of the course. Students described three ways in which their beliefs changed. First, students found mathematics to be more logical. Second, students became aware that they played a role in making the mathematics happen. Third, many of the participants experienced an increase in confidence. Many of the beliefs that were held by participants could be aligned with the class norms. Students claimed the course allowed them the opportunity to explore challenging problems, collaboratively discover the involved mathematics, and get less frustrated by working with others.

Inconsistencies. Foss and Kleinsasser's (2001) article provided insights into pre-service-teachers beliefs and practices as they undergo a mathematics methods course. The second part of a larger research project, the emphasis on the this aspect of the project was placed on the process of triangulating the data and illustrating the contradictory nature of pre-service teachers' beliefs and practices. Data sources included interviews, observation field notes, videotapes, audiotapes, artifacts (lesson plans, examinations, course assignments) surveys, grades, teaching evaluations, and the MARS. During the interviews that were conducted three times during the semester, open-ended questions were utilized to explore the pre-service teachers' beliefs about the teaching and learning of mathematics. The conceptions that the pre-service teachers held regarding mathematics remained the same throughout the course. Pre-service teachers focused their understanding on day-to-day activities, numbers and formulas. Findings indicated that the pre-service teachers found to believe that many of the aspects of the methods course (manipulatives, concrete experiences, etc.) were important to include, but were unsure about the implementation. As a whole, the pre-service teacher's MARS scores illustrated the reduction of fear and anxiety between the first and last class. Observations of their classroom experiences also provided evidence that the pre-service teachers were not implementing hands-on activities, despite discussions of their importance.

Schilling-Traina and Stylianides (2013) explored the change in beliefs of 25 pre-service teachers enrolled in a university elementary mathematics methods course. The course was developed to promote a problem solving as a process, instead of as a set of memorized procedures. Data sources for this study included written responses,

conceptual awareness pillars written as reflections, and individual interviews. Of the six individual interviews conducted from a random sample of volunteers, only two were incorporated into the study. The findings indicated that 8 out of 25 participants moved towards a primary or secondary problem solving view and that many of the participants' beliefs were resistant to change. These findings indicate that pre-service teachers' beliefs in the elementary mathematics methods course can be positively influenced. However, this research also indicates that the pre-service teachers previous views were resilient.

Changing in-service teacher beliefs through professional development. In teaching, there is a need for high quality staff development (Guskey, 1986). A large portion of staff development programs fail because they do not take into account two important factors: the process of changing one's attitudes and beliefs and a teacher's motivation to change. Teachers willingly take on additional responsibilities and attend staff development due to their belief that they will become better teachers and their students will benefit from the knowledge gained at the staff development program.

Guskey (1986) presents a specific sequence of events that must occur in order for staff development to change teacher beliefs and be considered highly effective. In his research, he examines and provides evidence for not only how changes are made, but also, how they are sustained. This model of change looks into how teachers change, and how teachers feel they become better teachers. First, it is essential that the staff development causes the teachers to change their classroom practices. If a teacher is successful with a classroom practice, he or she will keep it and continue to use it. However, if a classroom practice is initially unsuccessful, then the practice is most often

abandoned. After the implementation phase, there is a need to demonstrate that the new practice was effective. Frequently, teachers define their own success in their jobs by their students' achievements and failures. If a teacher feels that a staff development program or practice will not improve their teaching or benefit students, then the teacher will not likely change their teaching attitudes or beliefs and abandon the practice entirely. The implications of Guskey's findings are that change is both challenging for teachers and occurs gradually over time. The idea of a quick-fix staff development program will not result in the change of the desired teacher behavior or attitude. Instead, it is essential to provide feedback on the student learning process, and continued support after the initial training.

Raymond (1997) investigated the relationship between a beginning teacher's mathematical beliefs and practices. Data from six teachers was collected, but an emphasis was placed on Joanna, a fourth grade teacher, due to the dramatic and representativeness of her responses. The researcher utilized a combination of monthly interviews, classroom observations, evaluation of sample lesson plans, a concept-mapping activity and a take-home questionnaire. Joanna disliked mathematics throughout her education. While Joanna held primarily non-traditional beliefs, her teaching practices were found to be traditional. In addition to Joanna, data collected from the other participants illustrates the impact of teacher education programs only having a slight impact on changing practices, but a larger impact changing beliefs. The author surmises that this is due to the traditional beliefs being grounded in years of experiences. Raymond also implied that Joanna's mathematics content beliefs were deeply rooted in traditional methods, while her

pedagogy beliefs existed only on the surface.

A teacher educator redesigned a graduate mathematics course to not only include information about problem solving, but also engaged its participants to engage in an action research project in their own classrooms (Sakshaug & Wohlhuter, 2010). At least one hour of each class meeting was devoted to problem solving. Data was collected in the form of written reflections from their problem solving action research projects. The participants hit many obstacles along the way. At times they were successful with one problem, but not another. Sometimes group settings were used. Other times they were not. At times teachers recognized that they needed to facilitate student interactions, yet were unsure of how to without telling. Some teachers developed a strong positive disposition, while other teachers were still unsure about problem solving and had unstable beliefs.

According to Schifter and Riddle (2004), “the goal of teaching mathematics for conceptual understanding entails an instructional practice that treats mathematics as a realm of ideas to be explored rather than exclusively a set of facts, procedures, and definitions to be memorized (p. 32).” Yet, changing the beliefs of teachers of mathematics through the use of professional development is a challenging task. In order for teachers to re-evaluate their teaching practices, professional development must go beyond the typical workshop or lecture. Professional development must provide opportunities for teachers to develop highly connected understandings of mathematics as well as provide time for reflection, either orally or written. To help teachers understand what the new practice feels like, teachers in professional development should be treated

as students and forced to think outside of their comfort zone. Viewing teachers as students allows individuals the opportunity to see the desired practice modeled, explore mathematics, analyze student thinking, and examine their role as a teacher.

Warfield, Wood and Lehman (2005) developed a two-year professional development project to assist teachers in teaching a reform mathematics curriculum. The professional development was designed to be situated in practice and promote reflection. Seven primary teachers in their first few years of teaching were the participants in this study. During the summer each of the participants attended a one-week workshop that provided experiences to learn about the mathematical thinking of students, and the how curriculum materials could support their instruction. Data was collected to analyze and identify the actual and intended change in the teacher's practices. A combination of videotaping lessons, interviews, listserv messages and reflective journals were utilized to collect data. Once a month each participant would videotape a lesson, develop a plan of action based on a classroom dilemma, and reflect upon both the teaching and learning of that lesson. While all of the teachers adopted some reform practices, four teachers did not believe that their students could become autonomous learners. These teachers often interrupted their students' thinking, did not expect justifications, and did not reflect on their teaching or the learning of their students' mathematical thinking. The other three teachers taught the reform curriculum in a manner that promoted autonomy and reflection.

Barlow and Cates (2006) determined that professional development centered on problem solving in the elementary classroom impacted practicing teachers' beliefs about

mathematics and mathematics teaching. A sample of 61 elementary school teachers was taken from three schools in the southeastern U.S. A 24-question Likert-type survey was compiled with three open-ended questions in order to measure the teachers' beliefs. After its validation, the survey was administered as a pre- and post assessment of a year long professional development session focused on incorporating problem posing into instruction. A paired-samples *t*-test revealed a significant difference, indicating a change in beliefs.

The pre-existing beliefs that teachers possess and carry with them into the classroom have an impact on the manner in which they plan and implement instruction (Hart, 2002). Pre-service teachers enter education programs with preconceived notions that "mathematics is computation; mathematics problems should be solved in less than 5 minutes; the goal of doing a mathematics problem is to obtain an answer; in the teaching-learning process, the student is passive and the teacher is active" (Stuart & Thurlow, 2000, p. 115). Without recognizing and challenging these beliefs, the practices pre-service teachers incorporate into their classrooms will mirror their own counterproductive classroom experiences, instead of the current practices which better suit students and are endorsed by both the CCSSM (NGACBP & CCSSO, 2010) and the NCTM (2000).

Teach for America

The idea of TFA came from Wendy Kopp's undergraduate thesis in 1989 (www.teachforamerica.org). The primary goal of TFA is to ensure students from low-income communities receive an excellent education. Individuals in TFA dedicate at least

two years of teaching to an assigned low-income community. Those who serve their full two years are eligible to receive an education award from AmeriCorps up to \$11,100.

Individuals in TFA participate in a five-week institute during the summer that focuses on providing the essential frameworks, curricula and lesson planning skills that are required during their placements (TFA, 2012). Summer institute consists of several components including: summer school teaching experiences, observations and feedback, rehearsals and reflections, lesson planning clinics and curriculum sessions (www.teachforamerica.org/why-teach-for-america/training-and-support/summer-training). Individuals from TFA are then assigned a classroom of students for which they are responsible. During their first year of teaching, individuals are enrolled in professional development and content classes aimed at increasing the content and pedagogy required to teach elementary education successfully.

Acceptance into TFA consist of: a bachelor's degree from an accredited college or university, a high school diploma or equivalency certificate, a 2.5 minimum GPA, and proof that the individual is a citizen, national, lawful permanent resident of the United States (www.teachforamerica.org/why-teach-for-america/how-to-apply/applicant-prerequisites). TFA looks for individuals who share similar characteristics with TFA teachers who have made the most progress with students. These characteristics include both a deep belief in the potential of all kids and a commitment to do whatever it takes to expand opportunities for students. TFA Teachers are placed in low-income communities in which many students are performing behind their more affluent peers, at-risk of not finishing high school, and few, if any will have the opportunity of attending a four-year

college (www.teachforamerica.org/why-teach-for-america/training-and-support/teaching-as-leadership). These students who have the highest needs, attend schools that have few resources.

Perceptions. TFA students are more critical of their educational experiences and methods courses compared to traditionally certified counterparts (Carter, Amrein-Beardsley, & Hansen, 2011). Four instructors of five comparable sets of classes totaling 237 students, from both elementary and secondary programs, completed course evaluations and survey data. The findings indicated that TFA students wanted more from their methods instructors than their peers in a traditional teacher education model. Individuals in TFA cited that they needed ‘just-in-time’ knowledge. They wanted resources they could use immediately in their classrooms and viewed activities such as jigsaws and creating posters as fluff. They also wanted their instructors and associated universities to respect their time and the fact that they were already in the profession.

Three deans from American universities that partner with TFA discussed the benefits of the TFA program (Koerner, Lynch, & Martin, 2008). They believe that their university partnerships with TFA are extremely beneficial to the involved students and teachers; Especially in a time where providing long-term certification routes may not be what future teachers look for in choosing a certification route. Koerner, Lynch and Martin list the following as benefits of partnering with TFA: extensive professional development for faculty, gathering evidence to adjust both the content and sequence of courses, pre-service teachers gain experience grounded in the field, and experienced mentors (doctoral students) are provided to support and guide new teachers.

Improving the model. Hopkins (2008) proposes suggestions that she believes will improve the TFA program. As a TFA alumni that felt ill-prepared and ineffective, Hopkins recommends that TFA moves to a residency program and provides incentives for its alumni to stay in the teaching profession. Providing additional support and resources could possibly not only continue to recruit highly qualified, motivated individuals, but also benefit the involved students by providing them with knowledgeable, effective teachers.

Darling-Hammond (2008) provided reasons why the residency model is the answer to today's teacher certification crisis. She also explains that if TFA were to adopt this model, their program would truly be meeting the needs of future teachers. A residency program would allow pre-service teachers to receive guidance and support in the presence of an expert teacher, before entering into the profession. In this manner, teacher candidates would learn effective teaching strategies that would benefit all learners by providing high-quality instruction under the guidance of an experienced teacher.

Effectiveness. Darling-Hammond, Berry, and Thoreson (2001) found that students who have teachers that hold standard certification achieve at higher levels than students whose teachers are uncertified. They provide evidence that argues the previous assumption that less conventionally prepared teachers are more likely to be effective than traditionally prepared teachers. The authors cite several reasons for this belief. With regards to the sample, in the sample teacher population utilized in the previous research, many of the uncertified teachers had related content training and were perhaps teachers who held credentials in other states or districts. Ways in which the authors refute the

previous claim was through the clarification of licensing categories, re-analyzing the population of teachers in question, identifying other research on teacher education and certification and clarifying the coding of licensure categories.

Gardner's (2008) editorial stresses the importance at evaluating effective teachers not by their credentials, but by student performance. Gardner also argues that teacher certification does not provide enough evidence to predict the quality of graduates. Little emphasis should be placed on the fact that candidates are in the top 10 percent of their class or come from a highly ranked university. Instead, focus should be placed on the backgrounds of the candidates and the schools to which they will be assigned.

Darling-Hammond, Holtzman, and Gatlin (2005) replicated and extended an earlier study that examined the effects of TFA recruits in the Houston area. Data for this study was collected from students and teachers in grades three through five and over a period of six years. The researchers looked at a variety of variables including prior achievement, demographic information, teacher experience and education, classroom level demographics, and school level demographics. Upon first glance, the results were similar to those obtained previously citing TFA educators as having a positive effect on their students. However, since additional data sources were utilized, additional findings emerged upon analysis. Findings indicated that non-certified and TFA candidates not certified typically had a negative impact on student achievement.

Glazerman, Mayer and Decker (2006) wanted to know if TFA was making an impact in the classroom. They analyzed the test scores of 2,000 students from six areas across the nation. The positive impact of TFA on mathematics assessment scores was

statistically significant ($p < .01$, two tailed) for the overall full sample. However, for individual grade-levels 1-5, the results were only statistically significant ($p < .05$, two-tailed) for Grade 4. In math the average TFA class increased their rankings from the 14th percentile to the 17th percentile. The average control group started the year and ended the year at the 15th percentile.

Individuals in TFA teach in low-income areas and receive much of their training as they concurrently teach students (Carter et al., 2011; www.teachforamerica.org). This context of learning places TFA teachers in a unique situation for their elementary mathematics methods courses, as they are in need of resources that they can utilize immediately (Carter et al., 2011). Some perceive TFA could improve if they incorporated a residency model (Darling-Hammond, 2008; Hopkins, 2008). However, studies contradict the effectiveness of TFA. Some say TFA is an effective licensure path (Glazerman, Mayer & Decker, 2006), while others disagree (Darling-Hammond, Berry, & Thoreson, 2001; Darling-Hammond, Holtzman & Gatlin, 2005).

The Common Core State Standards for Mathematics

The CCSSM (NGACBP & CCSSO, 2010) were developed by the National Governors Association Center for Best Practices (NGACBP) and the Council of Chief State School Officers (CCSSO) to provide a common set of standards and increase the clarity of learning expectations among students, parents, educators and policy makers. The CCSSM (NGACBP & CCSSO, 2010) carefully created standards that:

are aligned with college and work expectations; are clear, understandable and consistent; include rigorous content and application of knowledge through high-

order skills; build upon strengths and lessons of current state standards; are informed by other top performing countries, so that all students are prepared to succeed in our global economy and society; and are evidence based. (NGACBP & CCSSO, 2010)

The CCSSM (NGACBP & CCSSO, 2010) represent a major change in standards for many states (Porter, McMaken, Hwang, & Yang, 2011) as they now place an emphasis on conceptual understanding as developed through scaffolded experiences. In fact, when the CCSSM were compared to previous state standards the consistency of coherence and focus ranged from approximately 60% to 80% (Schmidt & Houang, 2012). The CCSSM are research-based and sequenced to allow students maximum opportunities to build connections and make meaning of mathematics content. The CCSSM have also been designed to allow students access into Algebra by eighth grade.

The standards for mathematical practice. The standards for mathematical practice (NGACBP & CCSSO, 2010) stemmed from two foundational sources in mathematics education. The first is the NCTM (2000) process standards of problem solving, reasoning and proof, communication, representation, and connections. The second is from *Adding It Up* (2001), a report from the National Research Council, that identifies five strands of mathematical proficiency: adaptive reasoning, strategic competence, conceptual understanding, procedural fluency, and productive disposition. It is the combination of these two sources that make up the eight standards for mathematical practice of the CCSSM (NGACBP & CCSSO, 2010):

- make sense of problems and persevere in solving them;

- reason abstractly and quantitatively;
- construct viable arguments and critique the reasoning of others;
- model with mathematics;
- use appropriate tools strategically;
- attend to precision;
- look for and make use of structure; and
- look for and express regularity in repeated reasoning. (NGACBP & CCSSO, 2010)

The standards for mathematical practice (NGACBP & CCSSO, 2010) describe the manner in which the CCSSM (NGACBP & CCSSO, 2010) should be taught. Educators are expected to balance the use of procedures with conceptual understanding. Doing so provides students with opportunities to make connections both to the real-world and other areas of the curriculum.

Perceived needs. The NCTM issued a statement of support for the CCSSM (NGACBP & CCSSO, 2010) in August 2013 (NCTM, 2013). The NCTM believed the foundation provided by the CCSSM would promote a more rigorous mathematics curricula that promoted both conceptual understand and skill fluency. In their statement, the NCTM discussed how when properly implemented the CCSSM has the potential to increase the application and connectedness through high-quality mathematics. However, the NCTM also perceived five areas of needs in order for the CCSSM to be both implemented as intended and effective: (1) substantial opportunities for ongoing professional development; (2) accommodations in teacher evaluation systems; (3) ample

funding for education; (4) funding for research and implementation of Common Core assessments; and (5) adequate state funding (NCTM, 2013).

One article available that pertains to the elementary CCSSM (NGACBP & CCSSO, 2010) discussed the perceived needs of elementary mathematics teachers in Grades K-5 (Bostic & Matney, 2013). Two surveys were sent to 469 elementary school teachers asking what their perceived areas of need were with implementing the CCSSM (NGACBP & CCSSO, 2010). The top two areas of the content that teachers wanted future professional development to be centered on were Operations and Algebraic Thinking, and Numbers and Operations, specifically fractions. These were high-needs areas for students, as the failure rate the previous year had increased along with the sophistication in the state assessment. With regards to pedagogy, teachers wanted professional development that helped them to better understand the CCSSM, as well as additional support with developing student reasoning and the conceptual understanding now required.

Conclusions

Elementary teachers need to be aware that the mathematics they teach is not simple or basic (Lee & Kim, 2005). This perception may influence the pre-service teachers choice of problems or tasks as well as their own mathematical problem solving abilities (Patton, Fry, & Klages, 2008). At times when pre-service teachers think a student is struggling, they may attempt to lighten the cognitive load (Parks, 2004). Pre-service teachers may also prefer to avoid allowing students to struggle by picking problems that are less complex and more straightforward (Lee & Kim, 2004).

Traditionally, pre-service teachers have placed less emphasis on non-routine problems (Asman & Markovits, 2009; Crespo, 2003; Ellis, Contreras & Martinez-Cruz, 2009). Non-routine problems are often perceived as challenging and complex (Crespo, 2003; Ellis et al., 2009). Through ongoing collaboration and discussions within the mathematics methods course the perceptions of non-routine problems can be addressed (Asman & Markovits, 2009; Crespo, 2003; Ellis et al., 2009). However, a deeper understanding of the mathematics content can be discovered through the incorporation of problem solving into the mathematics methods course (Ambrose, 2004; Koray et al., 2008; Wilburne, 1997). Designing a mathematics methods course is a struggle many mathematics methods instructors continually battle (Andrew, 2006; Liebeskind, 2011; Raymond & Santos, 1995). However, the struggle can be worthwhile as the potential exists to foster positive attitudes (Alsup, 2004; Crespo, 2003; LoPresto & Drake, 2004; Phelps, 2007; Wilburne, 2006) and reduce mathematics anxiety (Bursal & Paznokas, 2006; Gresham, 2007, 2008; Malinsky, et al., 2006).

Pre-existing beliefs of pre-service teachers impact both intended and actual instruction (Hart, 2002; Scott, 2005) as many pre-service teachers experienced independent seatwork and direct instruction during their own mathematics experiences (Scott, 2005). The beliefs of these individuals are often traditional and grounded in years of experience (Raymond, 1997). Change in beliefs is challenging and occurs over an extended period of time (Guskey, 1986; Schifter & Riddle, 2004). While the material presented in the mathematics methods course can influence pre-service teachers' beliefs in a manner that is aligned with the CCSSM (NGACBP & CCSSO, 2010) and the NCTM

(2000) (Rolka, Rosken, & Liljedhal, 2009; Scott, 2005), changing beliefs is complex as new beliefs are added or discarded (Ambrose, 2004; Rolka et al., 2009). Many pre-service teachers value the importance of the information gained, but still feel unsure with how to implement it (Foss & Kleinsasser, 2001).

Previous research on changing problem solving practices of pre-service teachers has relied heavily on pre- and post-assessments utilized during the methods course (Ambrose, 2004; Davis & McGowen, 2001; Ellis et al., 2009; Lee & Kim 2005). Research on changing in-service teachers beliefs have focused on participation in professional development opportunities (Warfield, Wood, & Lehman, 2005). Previous research on teacher licensure routes has focused on identifying the differences in student achievement and teacher attrition. The researcher for this study was unable to identify any research on teacher certification routes and the implication of problem solving as a means to teach mathematics. The researcher also identified no research that followed pre-service teachers from the mathematics methods course into their first few years of teaching.

This study will provide both a unique perspective of the field of mathematics education in addition to filling a void in the literature by examining how the knowledge gained in the mathematics methods course is applied during the first years of teaching. This study will explore the influence of beliefs and background on novice teachers' perceptions of problem solving. This study also has the potential to provide a start to the exploration of how the beliefs from a mathematics methods course are sustained or perceived. In a time when both teacher education and teacher quality are closely

scrutinized, identifying characteristics between the relationships of teachers' experiences in teacher preparation courses and their experience as K-12 mathematics learners need further investigation to provide insight into opportunities and barriers for teacher professional development.

Chapter Three

The purpose of this study was to gain an in-depth understanding of the problem solving beliefs and perceptions of second-year teachers in a TFA cohort. The following research questions guided this study:

1. In what ways do personal and academic background influence the problem solving beliefs and perceptions of second-year teachers in a TFA cohort?
2. In what ways do the elementary mathematics methods course influence the problem solving beliefs and perceptions of second-year teachers in a TFA cohort?
3. In what ways do the implementation of the CCSSM influence the problem solving beliefs and perceptions of second-year teachers in a TFA cohort?

This chapter describes the research methodology used during this exploration. It describes the reasons a case study approach was taken, the evolution of the research questions, the identification and selection of participants, and the processes utilized for collecting and analyzing data.

A Qualitative Case Study

A qualitative approach provides an in-depth understanding of the phenomenon being studied (Merriam, 2009). Since the behavioral events could not be controlled, a case study approach was the appropriate choice. “Qualitative case studies share with

other forms of qualitative research the search for meaning and understanding, the researcher as the primary instrument of data collection and analysis, an inductive investigative strategy, and the end product being richly descriptive“ (Merriam, 2009, p. 39). A case study approach also maximized the knowledge gained from this unique research (Stake, 1995).

It is the determination of the unit of analysis and the ability of the case to be intrinsically bounded that sets the case study apart from other forms of qualitative research (Merriam, 2009). For the purpose of this research the final unit of analysis was multi-layered. The primary unit of analysis, $[x_1]$ was the problem solving beliefs and perceptions of individual second-year teachers in a TFA cohort who were perceived as individuals who “got” problem solving by their elementary mathematics methods course instructors. The secondary unit of analysis, $[x_2]$, was the similarities and differences that existed across the two cases. Participants were identified and served as individual cases, as they possessed common characteristics and conditions that arose from their personal, academic and professional backgrounds (Merriam, 2009). For these reasons, a case study approach was chosen to best illustrate the manner in which the participants’ problem solving beliefs and perceptions had been formed over time.

Evolving Research Questions

Initially I identified a list of flexible research questions so that I could respond to the influences of this study (Maxwell, 2005). The research questions were designed specifically to support a particularistic case study approach and not only focus on the identified phenomenon for what it might represent, but also by asking “how” and “why”

questions (Yin, 2009). Additionally, the literature base informed the design of the questions by: (1) narrowing down the focus of the study; (2) identifying voids in the current literature; and (3) providing support for the application of the questions. The initial research questions were not only aimed at exploring the perceptions and beliefs novice teachers possessed on problem solving, but also the impact that the elementary mathematics methods course had on the participants' problem solving beliefs and perceptions.

My original research questions centered on what I believed to be pivotal influences in any elementary mathematics teacher's career: one's personal and academic background and the elementary mathematics methods course. The research questions became more refined throughout the processes of data collection and analysis. Emic issues arose from the participants that were highly entangled in their problem solving beliefs and perceptions. The finalized research questions are a mesh of the initial intrinsic interest of the researcher and the interpretation of the data.

The Identification and Selection of Participants

Purposeful sampling was utilized as this particular situation was intrinsically interesting to the researcher (Patton, 2002). However, each decision made regarding participant criteria and selection not only shaped my data collection, but my research questions, data analysis, and findings as well (Reybold, Lammert, & Stribling, 2013). Initially I thought to explore the problem solving beliefs and perceptions of individuals from three different licensure paths: (1) the Professional Development School Year-Long cohort; (2) the Professional Development School Semester-Long cohort; and the Teach

for America cohort. Despite the fact that each of the licensure paths varied in longevity and field experiences, all three paths included an elementary mathematics methods course taught from the same university. Two instructors of the university's elementary mathematics methods course were interviewed and asked to assist in identifying individuals from each of the paths involved. The selection criteria for the participants included: (1) participation in an elementary mathematics methods course taught by faculty from the identified university; (2) completion of a teaching licensure program from the identified university¹; (3) the assignment of a full-time teaching position in an elementary classroom, kindergarten through sixth grade²; and (4) the mathematics methods instructor's recommendation that the individuals possess a good understanding of problem solving. Identifying participants with a good understanding of problem solving was essential so as not to compare individuals with vastly different understandings. Novice teachers were purposefully selected as they had recently completed a standards-based elementary mathematics methods course and also had the opportunity and time to apply the strategies, ideas and techniques taught into their own teaching.

The elementary mathematics methods instructors' interviews resulted in seven potential participants. Since the department possessed no database of program alumni, I utilized information from both the elementary mathematics methods course instructors and school districts' websites to identify the potential participants' e-mail addresses.

¹ Specific semesters for the enrollment in the elementary mathematics methods course are being withheld to protect the anonymity of all the participants.

² Specific years for the assignment of a classroom are being withheld to protect the anonymity of all the participants.

Once obtained, an e-mail was sent to each of the potential participants that explained the purpose of the research project, provided a timeline and asked for their participation. Out of the seven participants that were contacted, four individuals replied and three agreed to participate.

Participant demographics. Three teachers participated in this study: Kerri Sterling, Elizabeth MacKenzie, and Anne Jeffrey³. Two of the teachers, Kerri and Elizabeth, were TFA participants and taught in the upper-grades⁴ at different elementary schools within the same school district. Both Kerri, in her late-20s, and Elizabeth, in her mid-20s, were Caucasian and concluding their second full year of teaching, and as a result about to obtain their teaching licenses. Anne, a PDS Semester-Long alumna taught first-grade in a nearby school district. In her early-40s, she had just completed her first full-year of teaching with a teaching license. All three participants had been enrolled in a university elementary mathematics methods course. Despite the differences in timing of their coursework, all three teachers had the same instructor for their mathematics methods course, Dr. Alexandra Stephens.

Although three teachers were selected and participated in this study, one of the teachers, Anne, was dropped during the data analysis phase. Although, the data from Anne contributed to the research design, her experiences did not fit with the results of this study. As the analysis began, the data from Kerri and Elizabeth shared many similarities. Both individuals joined TFA after they had already completed their bachelor's and

³ Pseudonyms are used for all individuals to protect the anonymity of the participants.

⁴ The specific grade-levels are being withheld to protect the anonymity of all the participants.

master's degrees, were participants from the same TFA cohort, taught an upper-grade within the same school district, and implemented the CCSSM (NGACBP & CCSS, 2010) during their second year of teaching. Kerri and Elizabeth also had a similar background in which they disliked mathematics and had to self-advocate for themselves in order to become successful with the content. Although the data gained from Anne's interviews was valuable and also provided insight into the problem solving beliefs and perceptions of novice teachers, I made the decision to focus this study on the problem solving beliefs and perceptions of individuals in their second and final year of TFA. Further detail on each of the included participants is presented in the case analysis.

Teach for America. The two participants for this study were from a TFA cohort. TFA looks for individuals who share similar characteristics with TFA teachers who have made the most progress with students (www.teachforamerica.org/why-teach-for-america/who-we-look-for). They are placed in low-income communities in which many students are performing behind their more affluent peers, and are at-risk of not finishing high school. These students have the highest needs and attend schools that have few resources.

Prior to the start of the school year, the participants attended a five-week summer institute in 2011 that focused on providing the essential frameworks, curricula and lesson planning skills required during their placements (TFA, 2012). During their first year of teaching, the participants attended professional development and classes aimed at increasing the content and pedagogy required to teach elementary education. In the

spring of their first year of teaching, participants were enrolled in an elementary mathematics methods class located at a satellite campus of the identified university.

The elementary mathematics methods course. The participants in this study participated in the elementary mathematics methods courses offered by a large mid-Atlantic university. The university that provided the faculty for the elementary mathematics methods course is located in an urban area and is situated just outside a major metropolitan area. The university is one of the largest in the area and attracts students from all over the world. Utilizing participants from one university allowed for control of: (1) the influence of different philosophies and/or teaching styles of the mathematics methods course instructors; and (2) the content provided to the pre-service teachers during their mathematics methods course.

Data Sources

Multiple data sources were utilized for the purpose of this study. In order to identify the location of relevant data sources, the statement of propositions is important (Stake, 1995; Yin, 2009). Prior to beginning my research I identified the following propositions:

1. The personal and academic problem solving background of novice teachers will influence their beliefs and perceptions of problem solving. As a result, novice teachers may focus more on either problem solving heuristics or identifying the one correct answer in a problem when teaching.

2. Participants with a good understanding of problem solving, as observed by the elementary mathematics methods course instructor, are more likely to implement an embedded approach to problem solving as opposed to an approach focused on heuristics.

Interviews. In this study, I learned about the problem solving beliefs and perceptions directly from the participants. Each of the participants was interviewed three times using a semi-structured interview format (Merriam, 2009). A semi-structured format provided me with not only a list of common questions, but also allowed me the opportunity to respond to each situation in a manner that allowed the participant's views to emerge. The three interview protocols were used flexibly to deeply explore the participants' beliefs and perceptions of problem solving (see Appendices A, B, & C).

The first two interviews were conducted with participants individually. The third interview was designed to be a focus group of multiple participants to determine the problem solving perspectives and beliefs of each participant in a group setting. However, the focus group changed to an individual interview upon the actual implementation of the research. One reason for this change was due to the schedule requests of the participants. Since some of the interviews occurred during June, as the school year was coming to an end, the participants' schedules were often booked. Not wanting to seem unappreciative or demanding of their time, I allowed the participants to determine the interview schedules. An unexpected benefit of having a separate third interview instead of a focus group was the participants' comfort level with problem solving. Neither individual enjoyed mathematics in elementary school. Even as adults they admitted to lacking the

confidence in the accuracy of their solutions. Had others been involved in the interviews the participants might not have been as as focus groups are not appropriate for topics that are sensitive and highly personal (Merriam, 2009).

Each interview was audio recorded by the researcher and lasted for approximately ninety minutes. The purpose of audio recording was to capture each participant's exact words (Stake, 1995). During each interview the participants answered questions that were aimed at exploring (1) the participant's experiences with teaching and learning mathematics; (2) the participants' perceptions of teaching mathematics and problem solving; (3) the beliefs held regarding teaching mathematics and problem solving; and (4) the participants' criteria as to what constitutes a good mathematics problem.

Other data sources. During the participant interviews several documents were provided as additional data points: (1) an adapted version of the Good Mathematics Problems Questionnaire (Lee & Kim, 2005); (2) two mathematics problems for each participant to solve; (3) and the individual's results from the Beliefs Survey (Barlow & Cates, 2006). Each document was administered in order to develop a deeper understanding of the participants' beliefs and perceptions of problem solving.

Good mathematics problems questionnaire. The Good Mathematics Problems Questionnaire (GMPQ) was developed by Lee and Kim (2005) in order to determine how pre-service teachers rated and solved mathematics problems. It consisted of twenty problems to be rated by the participants on a scale of 1 (the example is poor or does not belong in this category) to 5 (the example is a very good problem). Problems consisted of both routine or traditional problems, as well as problems that were more complex in

nature. Characteristics of the problems included: multiple answers, multi-step problems, problems with extra or missing information, justification, puzzles, non-realistic problems, algebraic expressions, and problem posing.

Lee and Kim's (2005) GMPQ was adapted in several ways for the purpose of this research (see Appendix D). One of the first adaptations to the GMPQ was the clear identification and distinction of the rating scale. Other than identifying the codes for the scores of 1 and 5, other codes were not identified. As a result, I developed the following rating codes: Not A Good Problem (1), Somewhat A Good Problem (2), Undecided (3), A Good Problem (4), and A Very Good Problem (5). I also incorporated five additional problems. Four of the problems originated from an elementary mathematics methods course textbook and were identified from the chapter devoted specifically to teaching mathematics through problem solving (Van de Walle, Karp, & Bay-Williams, 2010). The fifth problem originated from the researcher and asked the participants to solve a simple addition problem in more than one way. The format of the GMPQ was also adapted to provide participants with enough room on each problem to solve, rate and explain their thinking. It was thought that incorporating an explanation would provide the participants with a reminder of their ratings during the interview.

Mathematics problems. Two mathematics problems were identified for the participants to solve. The Lion Cub Problem (see Appendix E) was found from an NCTM recommended resource (Krulik & Rudnick, 1998), and The Rabbit Problem was identified from an unknown source (see Appendix F). These problems were chosen due

to both the multiple approaches a participant could take and the accessibility and transferability to an individual teaching elementary mathematics.

Beliefs survey. In Barlow and Cates' (2006) study, the 24-item beliefs survey was used to identify the varying levels of pre-service teachers' beliefs that directly impacted their mathematics teaching (see Appendix G). Responses to the questions were arranged in a Likert-type format and ranged from 1 (strong disagreement) to 5 (indicating strong agreement). Eight of the survey questions were written so that a higher score indicated an alignment of beliefs between the participant and the NCTM (2000) standards. The remaining 16 of the questions were written so that a lower score indicated an alignment of beliefs and were reverse coded. The sum of all the responses was then calculated and served as the overall belief score, with a higher score indicating the participant's beliefs were more consistent with the NCTM (2000) standards. The beliefs survey was given to each at the initial interview to take home and complete.

Procedures. Once research consent was obtained from the university's Institutional Review Board (see Appendix H), contact with the elementary mathematics methods instructors was made. The instructors of the elementary mathematics methods courses were interviewed to gain their perspectives on their specific section(s) of the mathematics methods course utilizing a specific interview protocol (see Appendix I) and to identify individuals who met the participation criteria.

Potential participants were contacted via e-mails. Interviews with the participants were audio recorded. The location of the interviews was chosen by each participant (Merriam, 2009) due to both the convenience and public accessibility of the spot. The use

of audio recorders provided a tremendous amount of support. Not worried about taking down notes verbatim, I was able to be more engaged and attuned to each of the participants' mannerisms and gestures, as well as the subtleties of their tone of voice. Additionally, the use of audio recorders allowed me to take informal field notes that guided future ideas of thought for further inquiry.

The first interview centered on discovering each participant's problem solving perceptions and beliefs. At the conclusion, an adapted version of the GMPQ (Lee & Kim, 2005) and Beliefs Survey (Barlow & Cates, 2006) were provided to the participant with directions to bring them back to a subsequent interview. The second interview was centered on each participant's perceptions and beliefs of their mathematics teaching, with a specific focus on problem solving. The third interview protocol aimed at identifying the participants' beliefs and perceptions of good problems utilizing the GMPQ and two mathematics problems.

Data Analysis

The data collection for this study occurred over a relatively short period of time due to several factors including: (1) the timing of district year-end standardized assessments; (2) the closing of the academic year; and (3) participants' summer plans. Each participant completed all interviews over a period of no longer than three weeks. At times the data collection of one individual overlapped with another.

Transcriptions by a professional transcriber occurred immediately after each interview. Once completed, I immediately listened to each audio recording while reading the transcript and checking with field notes for accuracy and interpretive errors. During

this time I also jotted down questions and ideas that were triggered by the words of each participant and the rough observational notes taken during the interview (Maxwell, 2005). Listening to the audiotapes while reading and editing the transcription served as a refresher and assisted me with getting re-acquainted with each of the participants. A lapse of time occurred between the final interviews of each participant and the initial, more formalized start of data analysis due to the identification, determination and availability of additional participants. Initially, I had not expected so few people to respond to my dissertation assistance request. The flexibility of a summer schedule was beneficial to the interviewed participants, but created uncertainty with regards to the individuals who did not respond. Perhaps these individuals were away for the summer or not checking their e-mail. I contacted each of the individuals three times each, over a period of eight weeks.

Continued non-response from several individuals forced me to evaluate the continuation of my search for participants. Aware that the number of participants was not as important as the quality of the data, I wondered if I had enough data to thoroughly investigate and accurately report on my research questions. Introducing individuals who did not possess the same characteristics as my unit of analysis would change the dynamics of the participants, and as a result my study. Finding additional participants that did not meet the identified criteria would not assist me with maximizing what I could learn from this phenomenon (Stake, 1995).

I began analyzing the transcripts from the interviews in the order that I met with each of the participants. A within-case approach was first utilized to understand the complexity of each case in its own situation (Stake, 2006). Through the use of open

coding relevant information was identified (Corbin & Strauss, 1990). As I read through each interview, I highlighted words, expressions and information on the transcripts and recorded my own thinking of larger, summarized ideas and reflections in the margins. After each interview the identified information was recorded verbatim onto post-it notes. Once coding from all of one participant's interviews was complete, the post-it notes were then categorized to facilitate comparison and look for recurring regularities. Categories consisted of concepts from the data that pertained to the same phenomenon (Corbin & Strauss, 1990). After sorting the codes into categories I created a concept map in an attempt to find how each individual's groupings were connected. A master list of categories was created that merged identified categories from all three interviews (Merriam, 2009). After data from the first participant was analyzed the process was repeated for the second. I analyzed the cases separately so as not to merge the data too quickly (Stake, 2006). Upon completion of the individual concept maps commonalities between the two participants began to emerge.

After a within-case analysis, I utilized a cross-case analysis to better understand the similarities and differences of the phenomenon that existed between cases (Stake, 2006). In order to determine how the categories and findings were connected I created a matrix (Merriam, 2009; Yin, 2009). Categories of the initial participant were placed in the first column and relevant codes and reflections in the second. Once all categories were placed in the matrix, I grouped similar categories together and labeled them with a unifying theme. Similarities were determined by matching common wording or phrases from each participant. I then merged categories and codes from the second participant's

data sources into the matrix. Categories shared by the participants were aligned. The reduction of these categories led to the emergence of a select few themes. In this manner, I was responsive to the research (Merriam, 2009).

I began to analyze Anne's data in the same manner. I created an additional column in the matrix to determine how Anne's data fit into my analysis. At the point in which Anne's categories were being added to the matrix it became apparent that there were few categories that overlapped. I pondered over the issue, consulted with the members of my dissertation committee and reflected on the data that I had up to this point. By incorporating Anne the scale of my study would greaten, and along with it my unit of analysis. If I kept my study to include just Elizabeth and Kerri, I stayed true to my unit of analysis and tightened up the boundaries of my study. It was at this point that I made the decision to eliminate Anne's data from my study. In this manner I identified the data for my investigation that would receive the most focus and narrowed my study (Merriam, 2009). Full coverage of all emerging issues was impossible, and the search for meaning in this study returned to the primary focus previously set (Stake, 1995).

With the elimination of Anne, I focused my attention on the other data sources collected from Elizabeth and Kerri. Codes were identified and scores calculated from each of the active participant's beliefs surveys. The GMPQ was analyzed by looking at multiple aspects: final ratings of individual questions, the identification of good and not good problems, and the accuracy of each response. The multiple layers of the data afforded me the opportunity to dig deeper into the problem solving abilities, beliefs and

perceptions of each participant. It also provided me with insight into their comfort and capability with the mathematics content.

Research questions were modified and aligned with data to increase the relevance and understanding of the context being studied (Stake, 1995). I created a new matrix with the updated research questions, themes and categories. I went back to the transcripts once again to look for supporting data (Stake, 2006). Data unrelated to the updated research questions were analyzed to determine why it did not match and to re-evaluate the importance of its presence in my study.

Validity

Incorporating multiple sources into my research design was purposeful as it not only provided validation for my findings, but also provided evidence that made validity threats implausible (Maxwell, 2005; Yin, 2009). In this manner, construct validity was achieved. Internal validity was developed by searching for alternative explanations for the observed results (Maxwell, 2005; Yin, 2009). By ruling out alternative explanations, the plausibility and validation of my findings increased.

The primary source of data collection for this study was the interviews. While it is impossible to eliminate altogether the researcher's reflexivity, there are many ways in which I attempted to reduce the impact of my influence. I asked questions that were purposeful, open-ended and encouraged detailed responses (Maxwell, 2005). I not only avoided asking leading questions, I also asked clarifying questions to ensure that I was collecting accurate data and fully understanding each participant. I continually checked with participants to get their explanation of specific terms utilized in teaching that may

have been internalized or perceived differently. I also shared with each of the participants that they were personally recommended for this study by their mathematics methods course instructor as exemplars of problem solving in the mathematics methods course. It was my hope that identifying them as exemplars would increase their comfort and promote honest conversations.

The resulting data came in the form of self-reports. It was the participant's perceptions of their problem solving that this research aimed at uncovering. The teachers' anecdotes reflected their own personal lens into both their decisions to become a teacher and to understand their problem solving beliefs and perceptions.

The complexity of the selection process was revealed throughout this chapter to assist with building trust in both the methods and the presented results (Reybold, Lammert, & Stribling, 2013). Prior to making initial contact, I had no background knowledge or familiarity with the participants. While contacting and meeting each participant for the first time was initially awkward, I found that all three participants came to each interview willing to share their experiences. We met in locations of their choice, in their neighborhoods. I let them lead the conversations as much as possible. At times conversations were re-directed toward the protocol; however, as a researcher I valued the knowledge gained from each participant's train of thought. Multiple interviews with participants helped with building a trusting relationship over a period of time. By the final interview when the participants were asked to solve problems, many of them openly admitted that they were intimidated by the problem, not confident in their

process, or unable to come up with a solution. Without trust, the participants would not have felt comfortable divulging their honest reactions and emotions.

As an individual it is impossible for me to be unbiased; however as a researcher it is the awareness of my potential biases and my plan to deal with them that is most important. I explored the topic of problem solving because I am concerned about the teaching and learning of elementary mathematics. Many teachers still rely heavily on textbooks and believe that incorporating problem solving takes valuable instructional time away from the mandated standards. Yet some teachers incorporate problem solving and promote many of the mathematical practices that elicit student understanding and engagement. Throughout the study, I viewed my experiences as a pre-service teacher, in-service teacher, elementary mathematics resource teacher, graduate student and elementary mathematics methods instructor as beneficial. I had similar experiences to draw on and relate to, as well as an understanding of the uncertainties, demands, and rewards of the profession.

Limitations

The stories of the participants identified for this study are unique and not replicable. The final report is written using the data and perceptions of only two individuals. A sample of two individuals was not likely to represent an entire population; however, a case study approach was not identified for the generalizability of this research (Stake, 1995). Certain commonalities existed between the participants that potentially will hold true and relate to the lives of others (Merriam, 2009). Whether it is the initial transition from state standards to the CCSSM (NGACBP & CCSS, 2010), the struggle

some teachers have with changing their mindset and adopting practices that look different from those that they experienced as learners of mathematics, or the difficulty of truly mastering the content of mathematics and understanding the how and why behind the computation, individuals who teach mathematics will make connections with various parts of this study.

Boundaries

This research was focused on gathering only the participants' perceptions and beliefs. This research did not attempt to gather documentation regarding the implementation of problem solving within the participants' classrooms to identify what actually occurred. It may be that the teachers' behaviors and actions within the elementary classroom differed from their reported perceptions and beliefs. Throughout the research process, the teachers' perceptions appeared honest and reflective. They admitted their flaws and faults as teachers, and also came to some moments of deeper understanding of their own practices. This was not the intent of the line of questioning, but each of the participants took on the interviews to further their own understanding of mathematics education. They were already looking to reflect on their practice.

Chapter Four

The organization of the findings are presented in three major sections: (1) academic and personal backgrounds; (2) the elementary mathematics methods course; and (3) the CCSSM (NGACBP & CCSSO, 2010). Throughout each section the influences on Elizabeth and Kerri's problem solving perceptions and beliefs are described. Overall, the women shared many similar experiences over the course of their lifetimes. However, how each of these experiences influenced their problem solving beliefs and perceptions differs as evidenced in Table 1.

Table 1

Comparison of Influence on Problem Solving Beliefs and Perceptions by Participant

<u>Influence</u>	<u>Elizabeth</u>	<u>Kerri</u>
Relief of Math Anxiety	Sacrificing time	Conceptual understanding
Teach for America	"Buying herself time."	"A means to an end."
Problem Solving (EMMC)	It's not where I am.	A reluctant buy-in.
CCSSM Emphasis	Content standards	Process standards
Problem Solving (CCSSM)	Differentiation	For all
District Assessment	Drives instruction	"Necessary evil."
Impact on Students	"Impact those I can reach."	Impact all.

In terms of their views on problem solving Elizabeth and Kerri's backgrounds influenced them similarly. Both women struggled with understanding mathematics and developed a hatred and anxiety towards mathematics. However, while Elizabeth's successes focused on giving up her time and following a sequence of steps, Kerri's success required that the material be presented in a way she could access it so she could develop a conceptual understanding. In terms of problem solving, the manner in which each achieved success influenced their beliefs and perceptions.

Academic and Personal Backgrounds

Elizabeth and Kerri shared a similar background. Their struggles throughout their mathematics experiences fostered a deep hatred and anxiety of the content. Their only relief came when they learned to advocate for themselves. Both attended 4-year universities in fields other than education and came to the region to further their studies and obtain a master's degree. Nearing completion of their master's degrees and not ready to commit to their decided career paths, both decided to join TFA. For one teaching was something more meaningful than an internship; for the other it was a 'means to an end.' In their minds, neither was the typical TFA applicant. In their mid- to late-20's and already possessing master's degrees Elizabeth and Kerri got their first choices for both location and grade band preference. Both Elizabeth and Kerri were placed in upper-grade classrooms in some of the roughest areas of the district, both physically and academically. With no resources and no teammates the two were pretty much left on their own to map curricula and meet the needs of their diverse learners. The second semester

of their placement the two were enrolled in an elementary mathematics methods course where the big take-away messages were similar, yet implemented differently.

Anxiety in school. At all stages in their lives, Elizabeth and Kerri were anxious about learning mathematics. Whether it was elementary or high school both women hated mathematics as children to the point they would physically get sick and suffer from stomachaches. Neither of them enjoyed learning mathematics as a result of their anxiety and constantly shed tears. Family members attempted to support Elizabeth and Kerri with their mathematical understanding; however, it was their ability to self-advocate that ultimately led them to achieve scores of success.

Elizabeth: Anxiety relieved by sacrificing time. Learning mathematics was a ‘nightmare’ for Elizabeth. Her earliest memories of learning mathematics were filled with confusion and anxiety. In first-grade when trying to solve a missing addend problem, Elizabeth’s anxiety was heightened due to her teacher’s impatience.

The problem was six plus box equals number. I vividly remember her knocking on the table. ‘Hurry up we’ve got to get to the next one.’ I was just so confused. I ended up crying. I didn’t know what number the box was. It was so traumatic it stuck with me all these years because I literally thought [box] was a number that I had never seen before. (first interview)

Over the years, Elizabeth’s anxiety continued to increase when she was unable to produce an answer.

As early as second grade, Elizabeth struggled with math homework. From the moment he walked in the door, Elizabeth would work with her father on her homework.

Even after one to two hours, the assignment was often incomplete. In these instances, her father would write notes to the teacher asking for extensions. Elizabeth was always required to fulfill her student responsibilities. Even with hands-on projects Elizabeth struggled. Her parents attempted to relieve Elizabeth's anxiety by buying additional workbooks to supplement at home. However, reflecting on their support, Elizabeth wished they had done more than provide workbooks and additional practice.

One thing I wish they'd done is advocate on my behalf knowing that I struggled so much. Instead of just being like, 'Well you're no good at math.' Try and reach out and get a resource which might be helpful. That was one thing I wish they had done different. (second interview)

The trauma of learning mathematics continued through high school. Elizabeth initially wanted to drop mathematics as soon as she completed her two years required to graduate. However, upon researching college entrance requirements, all of her desired schools had mathematics prerequisites of four years.

Success in learning mathematics came for Elizabeth when she began to self-advocate. As Elizabeth got older, she recognized her struggles and was able to seek additional support after school. However, the responses from her teachers were not always supportive. In tenth-grade, she went to her teacher for additional assistance after school. The help the teacher provided was rushed. Elizabeth walked away with little knowledge gained.

Elizabeth began to search for support elsewhere. The resource center at her high school was available throughout the day and was staffed with an individual who provided

mathematics support. Unfortunately, his assistance was often in high-demand. He provided students help with one problem and then left to assist others. Often Elizabeth was left waiting for support. Her frustration increased. “I remember breaking down and crying one evening at home. My parents said if you want to get a tutor, you can get a tutor. And it was like the heavens opened up” (second interview). The tutor Elizabeth hired was the mathematics instructor from her high school’s resource center. Her tutor knew the shortcuts and taught them to Elizabeth so that she would have enough time to complete her tests and assignments. In addition to receiving support from her tutor outside of school, Elizabeth went to the resource center as often as she could. She went to the resource center before and after school as well as during study hall. Elizabeth even stopped eating lunch her junior and senior year so that she could get mathematics support at that time. Elizabeth believed it was the act of giving up her time that led to her success. “That’s what it took for me to become an A student in pre-calc. I was a B and C student before I gave up my lunch” (first interview).

Kerri: Anxiety relieved by conceptual understanding. In fifth-grade Kerri’s troubles with mathematics began. “I cried all the time with math. I just didn’t get it. I would just sit there. I’m a very type-A personality so I didn’t like not getting it, which made me that much more frustrated” (first interview). A perfectionist who loved school, Kerri clearly remembers the first time she failed anything. “It was a math quiz in fifth-grade. And to this day I can never forget that shame. I felt I just couldn’t understand” (first interview). The quiz was on converting units of measurement. Kerri was

overwhelmed with the amount of information needed to memorize and had no conceptual understanding of what it meant to measure.

I'm still terrible at converting. It was the most painful thing I went through because I just didn't get it. Now thinking on it as a teacher, no one handed me measuring cups or tablespoons or yardsticks. It was just memorize this formula.

(first interview)

Although the real-life application was never made and Kerri struggled, she never faulted her teacher. In fact, as she entered teaching, Mr. Pollock was the teacher that Kerri channeled.

He was the best teacher I ever had. He made you want to learn, and not because he wanted you to learn. Math was everywhere. Learning was fun, other than that measurement unit. Once he sat me down and we had 'the talk' math started to become fun again. I realized if I asked the right questions, this wasn't so bad. It wasn't that I didn't get long division. I didn't get one step. (first interview)

Mr. Pollock explained to Kerri how learning worked and helped her to realize the real-world application of mathematics. Mathematics was not constrained to the math block. In the middle of spelling he would spontaneously announce it was time to play math basketball.

Proclaiming that she was no good at mathematics, Kerri's mother was unable to provide support at home; especially as the complexity of the mathematics increased. At home Kerri bartered services with her older brother: math for reading. Even with the

support of her brother Kerri's anxiety and negative perceptions of mathematics continued.

Overall, I hated math. I really hated it. Which I think, has made me a better math teacher because I had to learn things three or four different ways. So if I didn't understand how to find the circumference. I mean what does that mean anyways? It wasn't until I kept saying 'I don't get it! I don't get it! Someone tell me what I'm doing!' When someone [finally] gave me a conceptual understanding I was like, 'Oh! Why didn't you just say that?'" (first interview)

Math was fine for a few years. A linear thinker, Kerri loved algebra, its efficiency and the rules that worked every time. However, when she entered geometry, the anxiety and stomachaches returned. Citing no spatial reasoning, Kerri struggled with geometry. Kerri remembered the life lessons from Mr. Pollock and began to advocate for herself.

You need to be assertive. You need to be a self-motivated learner. No one's going to hand you something in life. [Mr. Pollock] taught me if you don't ask the right questions people are going to pass you by. He also taught me how to ask questions and advocate for myself as a learner. Which helped me when I got to geometry and had no idea what was going on. Essentially I had to demand my teacher teach me or I was going to walk out. I had to advocate for myself. I had to go to the principal and say [my teacher's] not teaching me. What are you going to do about it? I was 14-years old, with the confidence that I deserved a good education, and someone was going to give it to me. (first interview)

Even with her newfound confidence Kerri struggled when she took trigonometry. For Kerri there was no real-life application and often she was left wondering “Why do I even have to learn this?” In pre-calculus the connections failed to be made once again. Without a purpose for learning Kerri was lost, especially on her final. Overwhelmed and confused Kerri gave up. In frustration she wrote ‘He should go to Home Depot, because I don’t know what to tell you” (first interview). Even though Kerri knew what skill was being assessed she did not understand either what to do on the problem, or why math had to be so hard.

TFA as an entry into teaching. Neither Elizabeth or Kerri grew up wanting to be a teacher. Yet both ended up joining TFA. In their mid- to late-20s each identified TFA as the next step they wanted to take. TFA was identified because the career path they began after high school was either unsuccessful or no longer interested them. Neither was willing to move away from their location; both wanted to stay where their master’s programs had brought them. Unsure of where their journey would take them, they began by applying to TFA to become a teacher.

Elizabeth: Buying herself time. At 24, even with a master’s degree, Elizabeth had difficulty finding a job. Elizabeth wanted a ‘legitimate, meaningful position.’ She did not want to be *just* a receptionist at a think tank or someone who filed research. “Maybe in a couple of years I would be in a place where I could eventually accept that that’s where I’m going to have to start. But at that point I couldn’t accept that” (first interview).

Elizabeth thought the thing missing from her experience was a name brand. Both schools that she attended were small and not well known. However, outside of taking a

clerk position or an internship, few opportunities existed. Elizabeth explored the idea of teaching as a way to buy herself time. A Facebook friend thought that Elizabeth would be a perfect candidate for TFA with her experience as a babysitter and local foreign language teacher.

I always toyed with the idea of teaching. Multiple people always said I should teach. I wanted to keep myself here. I wanted to do something meaningful. And I kind of wanted to try and boost my resume in terms of caliber. Teach for America has a really good reputation, and that's why I decided to try it. Had I gotten into [another location] I would not have taught (first interview).

Elizabeth did not anticipate being a career changer so she was very careful in her evaluation of the programs she researched. Traditional routes to teacher certification did not offer immediate pay and entry and required Elizabeth to pursue licensure at her own commitment and expense. TFA offered a master's option, which was a must for Elizabeth. With the grant from AmeriCorps that covered the majority of expenses, TFA was also financially feasible. "I didn't anticipate being a career changer so I didn't want to invest the money into this." (first interview)

Kerri: A means to an end. Nearing the completion of her master's degree, Kerri knew that she didn't want to work overseas for a large corporation. Kerri knew for certain that she wanted to become a teacher, yet was uncertain which path would best suit her needs. A friend recommended TFA and her interest was piqued. Upon closer examination, TFA became a viable option; especially with the financial support from

AmeriCorps. With her desire to become a lifelong teacher, Kerri was confident about her ability to get into the highly competitive TFA program.

I knew that I had some bargaining power because I was a little bit different from most people applying for TFA. I wasn't 21. I wasn't right out of college. I had a graduate degree. I knew I'd be good for statistics. (first interview)

Joining TFA was "a means to an end" (first interview). Kerri would receive her teaching license, a second masters, immediate pay, and have little to no financial obligations with the support from the AmeriCorps grant.

The Elementary Mathematics Methods Course

Upon initial entry into the classroom both Elizabeth and Kerri were assigned upper-grade classrooms and were responsible for teaching mathematics. However, it was not until their second semester that they were enrolled in an elementary mathematics methods course. Throughout the course their professor, Dr. Alexandra Stephens, exposed them to problem solving through weekly problems, the use of manipulatives, the designing of lesson plans, and a clinical interview. The weekly problems and manipulatives are what they remember best.

In terms of Elizabeth and Kerri's views of problem solving, their approaches differed. Elizabeth viewed problem solving as something neither her nor her students were ready for. While Kerri initially viewed problem solving as something that would not work for her students, by the time she completed her elementary mathematics methods course she valued problem solving very much.

Elizabeth: It's not where I am. The elementary mathematics methods course became a safe place for Elizabeth to learn.

I felt comfortable. I felt very capable again. Alexandra did a very good job of being a supportive person. It was clear that a lot of kids were getting it more quickly than me. It was clear that I was the one mixing things up more than the other kids. That fact hasn't changed. I don't get it nearly as quickly as the other kids do. But it's not like I left not getting it. Alexandra was always willing to stay afterwards to help. (first interview)

It was a relief for Elizabeth not to have the anxiety imposed on her by an impatient teacher. "She taught us how to think. Not just how to teach" (first interview). Dr. Stephens was supportive of Elizabeth's growth.

In the mathematics methods course, problem solving occurred on a regular basis. Each class opened with a problem and provided students with an opportunity to share their multiple strategies. As peers presented their methods and solutions, Elizabeth was often confused. As a result, Elizabeth tended to gravitate towards one way of solving each problem and shut out the other ideas. Her peers were not always as accepting of the fact that Elizabeth did not 'get it' right away. "Sometimes I stayed in my own little corner to figure it out while everyone moved on" (first interview).

Even though Elizabeth loved the class, she was disappointed that the content focused on all elementary grades, instead of just on the content she needed. Elizabeth recognized that she might not always be an upper-grades teacher. However, the demands placed on her by teaching full-time were prioritized over her learning mathematics. Much

of what Elizabeth learned from her elementary mathematics methods course did not immediately transfer to her teaching. “My methods course was more discovery-based. It isn’t where I was and not where I am now” (first interview). Elizabeth believed that many of the ideas from her methods course were really engaging and beneficial to students, she just didn’t think she had the time or resources required to implement the new ideas with fidelity.

Prior to the elementary mathematics methods course Elizabeth did not utilize manipulatives. She simply did not have them available to her and did not realize their importance. At one point, while enrolled in the elementary mathematics methods course, Elizabeth made paper fraction models for her students. The management of the manipulatives was difficult as pieces were continually lost or damaged. As a result, Elizabeth decided to place an emphasis on the equation and leave it at that.

You’re not going to learn so much what a fraction is, you’re just going to learn how to do all the different operations. We’re going to learn to multiply and divide and you’re not going to know [conceptually] what that means. (second interview)

Once the methods course concluded, Elizabeth required her students to explain their thinking by recording their steps. Elizabeth’s quicker learners were able to articulate their thinking and provide step-by-step rationales. However, Elizabeth was frustrated that the vast majority didn’t explain their thinking to her standards. “I think a part of it is laziness. They don’t like to write and I require a half page of writing” (second interview). Despite Elizabeth modeling written math responses using a both a gradual release approach and the analysis of good and bad examples, her students still struggled with

explaining their thinking. Elizabeth decided to hold off on incorporating the *why* in her students' responses. They just were not ready.

Kerri: A reluctant buy-in to problem solving. Kerri felt dejected as a first year teacher. Her students were constantly struggling in math. The gradual release model provided by TFA was not working for her. "I didn't know what I was doing. I was just struggling to make it to the next day hoping no one gets killed and someone learns something" (first interview).

Initially Kerri was scared of the elementary mathematics methods course. She felt like a struggling student again. In every class Dr. Stephens provided manipulatives. While Kerri enjoyed experiencing the manipulatives she often did not know how to use them. Due to her discomfort and unfamiliarity manipulatives were never provided to Kerri's students. Retrospectively, Kerri believed the lack of manipulatives was probably a detriment to her first class, and she wondered where they could have gone if she had provided the appropriate tools.

Kerri panicked upon seeing the open-ended problem on the board her first class. She had no idea what to do or where to begin. Kerri immediately empathized with her students. Kerri's primary tool for any type of problem was a standard algorithm. Each week as her peers went to the board and explained their thinking Kerri knew she did not have an accurate answer. However, she was okay with that. "It was interesting to see all the different ways my peers solved the problem" (first interview).

Kerri was reluctant to try problem solving. The entire time she was in the mathematics methods course she was convinced that a problem solving approach would

not provide her students with success. Seeing her reluctance, Dr. Stephens constantly pushed Kerri to extend herself and try problem solving. Each time Dr. Stephens pushed, Kerri pushed back. Kerri finally gave in and tried problem solving with a small group of four students. Kerri did not have the courage or confidence in her management to try it with everyone. However, the results were amazing.

Just seeing how many skills were involved with a ten-minute problem-solving lesson. They were using every part of their brain. They're building. They're drawing. They're coloring. They're explaining. They're writing. Wow! That hit so many standards right there and they got so much more out of class. That's when I fell in love with teaching math. When I saw how much you could do with one lesson. (first interview)

The last few weeks of the school year, Kerri changed her approach to teaching mathematics. She stepped away from the gradual release model that she had been using and incorporated problem solving. For Kerri, the elementary mathematics methods course 'revolutionized' her confidence in both her own ability and her students' to learn. Through problem solving Kerri realized her students were capable of deep thinking. She just needed to give them the opportunity.

The elementary mathematics methods course also helped Kerri to realize that learning math was not as complicated as she had internalized over the past twenty years.

I was happy about it because it helped me blame my teachers a lot more than myself as a kid. They just weren't teaching me well. But I felt more prepared as a

teacher because I realized it wasn't this pink unicorn we were chasing. I realized that I can do this. (first interview)

The Influence of the CCSSM

Both Elizabeth and Kerri taught the same grades again their second year of teaching. However, while many second-year teachers can apply and reflect on the teaching of the content from their first year, Elizabeth and Kerri were unable to do so due to the implementation of the CCSSM (NGACBP & CCSSO, 2010). For Elizabeth and Kerri the adoption of the CCSSM meant all new standards. Both teachers felt as if they were first-year teachers once again. During this time Elizabeth stayed at the same school, while Kerri was forced to switch schools as hers shut down. Kerri followed her assistant principal to another school within the same district.

The CCSSM (NGACBP & CCSSO, 2010) was a major influence on both Elizabeth and Kerri's problem solving beliefs and perceptions. With the new increased rigor of the standards, Elizabeth focused on the content and believed mastery was required before students could problem solve. As a result only a few students experienced problem solving during the mathematics block. Kerri focused on the standards for mathematical practice (NGACBP & CCSSO, 2010) and believed that teaching the content through problem solving would benefit all of her students.

Elizabeth: A focus on content. From Elizabeth's perspective she was thrown into teaching the CCSSM (NGACBP & CCSSO, 2010). While not having materials from the previous year that transferred was a pain, Elizabeth's biggest challenge was not having enough training and time to implement the CCSSM with fidelity.

I had to do a lot of relearning myself. And because of time, I didn't have the time to do what the Common Core was asking me to do with any particular standard. I just didn't have a grasp on the material. I was better versed than last year. I had more support in terms of resources. But I was still not where I think I should be when I'm responsible for teaching all these young minds. (first interview)

The implementation of new standards greatly impacted Elizabeth's students. The transition between standards left students with gaps of knowledge that were not addressed in the new curriculum. Elizabeth struggled with delivering both the content she was required to teach and the background knowledge her students' required. The lack of a solid foundation in the CCSSM (NGACBP & CCSSO, 2010) led Elizabeth to adjust the content at times when she felt it was too difficult or challenging for her students. Often she did not understand what the CCSSM were asking her to do. Not fully understanding the concepts herself was the most challenging aspect of teaching the CCSSM.

Elizabeth's struggles with the content were sometimes relieved by her teaching assistant whom she referred to as her 'lifesaver.' Elizabeth regularly made content mistakes both in front of her students, and on classwork and exit tickets. Often her assistant would double-check her work to ensure that there were no mistakes. Elizabeth's confidence level decreased when her assistant was not present.

At times, Elizabeth's uncertainty of the content entered into her classroom. During these times, "If I got stuck in class, I would just abandon the problem and switch the content. Move on to science. Not necessarily a clean ending. But that isn't a bad thing in math" (third interview). At times, Elizabeth encountered difficult problems while looking for materials for her lessons. If her understanding of the content did not allow her to successfully explain the concept to her students, she would sift through and filter the problem to make it more manageable for her students. "That's when I would decide to use one part, and not the complex part" (third interview).

In some ways the implementation of the CCSSM (NGACBP & CCSSO, 2010) supported Elizabeth's growth as a teacher. In contrast to the previous year, a clear scope and sequence was provided. Elizabeth, a novice teacher, was no longer required to order and pace each standard for herself. Additionally, two large tubs of manipulatives appeared in Elizabeth's classroom. The resource, Hands-on-Mathematics from ETA, initially overwhelmed Elizabeth who was primarily focused on understanding the challenging content she was required to teach. Having the manipulatives was a game changer for her students the second year. Even though Elizabeth's students struggled with understanding and applying the traditional algorithms they could access problems with the support of the manipulatives.

While implementing the CCSSM (NGACBP & CCSSO, 2010), Elizabeth focused solely on the her grade level curriculum, and was unaware of the vertical connections between grades. It was her assumption that if her students were not exposed to a particular aspect of the content with her, the content was embedded somewhere else.

One of my most challenging lessons was a remediation on how to divide remainders. I thought that was something ideally you should know, but they didn't. So I haphazardly made the lesson with little unit blocks and different squares. I tried paper and stickers. I don't know. The kids didn't really get it. It was just one of those things that we needed to move on. We didn't have much time. But I also didn't do a lot of research on how to teach division. Part of it might have been that I didn't give it as much planning as I did other things.

(second interview)

Elizabeth felt that the high expectations and difficult content of the CCSSM (NGACBP & CCSSO, 2010) limited her teaching of mathematics. In Elizabeth's mind, the new standards could not support problem solving as the requirements of the content were too deep. Elizabeth felt that her students lacked the background knowledge and connections that were required to be successful with the CCSSM. To support them Elizabeth provided a scaffolded sequence of steps that were posted on anchor charts. However, Elizabeth soon found that her students were not successful with the steps.

The kids got bogged down in the steps even though we had the acronym. They always put it on their paper, but they still had a difficult time. I tried to make them check off each letter, but they wouldn't do it. It was laziness (second interview).

Elizabeth began her second year wanting her students to discuss mathematics. Initially, Elizabeth determined the partners in her class. She identified two individuals who were not close friends so that the conversations would remain focused and on-task. However, due to management Elizabeth ended up sitting her students next to people they

would not normally associate with to discourage talking. The students in her class revolted at this idea. Not wanting her students to have off-task behaviors that were more difficult to manage, Elizabeth did not regularly implement discussions. Instead, Elizabeth's students spent the majority of the time doing independent seatwork.

A combination of the CCSSM (NGACBP & CCSSO, 2010) and district assessments also left Elizabeth feeling constrained by what she could do to build connections and increase authenticity for her students.

They always said you can bring in real-world items. But I felt like if I wanted to make it at the level they wanted, I'm not necessarily going to be able to make a real recipe. It's just going to be some kind of mush or something. (third interview)

For Elizabeth, hands-on mathematics was not as rigorous as the expectations set by the CCSSM and assessed by her district.

At the close of her second year of teaching, Elizabeth's comfort and confidence as a teacher increased. "I feel more comfortable. Even though it's Common Core. It's so different from last year. I feel a little more confident. But I didn't realize math could be so complicated" (third interview). Elizabeth admitted she was more comfortable this year than last. However, she was not comfortable with all of the math concepts taught. During the interview, Elizabeth was often unaware she had made any errors.

Certain things like division of fractions. I can show you a model or a drawing of what that would look like. I could show you with manipulatives what that would look like. But when you ask me to explain the formula, I can't. That's frustrating

because I should be able to understand it to tell kids. There's still some concepts that I am just going to jump to [the equation] and [the students] are not going to ask questions, hopefully. Because I don't know. (first interview)

Problem solving as differentiation. When asked to define problem solving Elizabeth provided the following description:

You get some type of problem. In my mind it tends to be a word problem, but that doesn't necessarily have to be the case. It's something you've kind of been exposed to, but maybe not fully, and you have to come up with an answer. You can use manipulatives. You can use pictures. You can play around with what you have, the strategies in your mind, to come up with the correct answer. You can talk to other people. And then you have to explain it articulately. (second interview)

The implementation of problem solving in Elizabeth's classroom was rarely done with her whole class. "I did it more earlier on. I kind of shied away from it because it became difficult to organize the materials and the management aspect of it, keeping them on task" (second interview). Elizabeth identified several reasons problem solving implementation was difficult in her classroom: (1) the complexity of the CCSSM and the inability of her students to be successful with the content first; (2) the difficulty of managing students and materials; and (3) the students' lack of perseverance.

Elizabeth's students needed a lot of support with the increased difficulty of the CCSSM (NGACBP & CCSSO, 2010). Prior to attempting problem solving, Elizabeth wanted to ensure that her students had a solid foundation of the content. Elizabeth

frequently utilized an anchor chart with outlined steps to introduce content to her students. She would then demonstrate how to first use a picture to solve, and then the equation. The majority of Elizabeth's students had such difficulty with learning the steps that Elizabeth felt she couldn't move on to problem solving.

In Elizabeth's class, there were so many struggling students she had difficulty providing them all support. If Elizabeth focused on one kid at a time, many of the students' needs were not met. However, when she attempted to pull small groups the challenges continued as off-task behavior lead to student disengagement. Instead of problem solving, Elizabeth looked for something her students could do independently without her support. Allowing the students to work on reading responses and independent reading was more manageable. Instead of a 90-minute math block, Elizabeth pared hers to 60 minutes and devoted 30 minutes to reading. Doing so made teaching mathematics more manageable for Elizabeth. "Everyone's doing the same thing. For the most part people don't need help because they are reading a book at their level" (first interview). As a result of the difficulty of managing her class, the majority of Elizabeth's mathematics instruction was presented whole-class.

As a district-emphasized practice, Elizabeth attempted to introduce problem solving into her teaching multiple times. One successful problem-solving lesson involved using Venn diagrams to compare and contrast various geometric shapes.

It wasn't one of those lessons where I felt a lot of kids were lost, where I was pulled in a lot of different directions answering questions. After the initial approach with a lot of help, they were able to look at it, use the vocabulary

correctly, name the number of attributes to each shape correctly. They were able to see that two shapes even though they were completely different still had things in common. In my mind, they were able to juggle so many different facets that I was requiring in this problem without me having to be right there. (second interview)

Not all of Elizabeth's attempts at problem solving were successful. Elizabeth learned about open-ended problems from a district professional development. Enthusiastic about the possibilities for differentiation, she immediately attempted a problem with her class. Elizabeth's students did not share her enthusiasm and were confused by the fact that there were multiple answers.

Elizabeth's students struggled most with the perseverance of problem solving. When presented with a problem, Elizabeth's students quickly did the math and wrote a one-sentence explanation. This effort fell short of Elizabeth's expectations of a one-half page explanation of the steps used to solve the problem. "I think it's a demographic thing. Our kids just aren't used to being pushed at home" (third interview).

While problem solving was difficult to incorporate whole class, Elizabeth was able to implement problem solving with small groups of students. Throughout her second-year, Elizabeth utilized problem solving to differentiate her instruction.

I would see that this large group didn't get it, but then these seven kids had it. They're not going to sit there on a lesson with me, on the same stuff because they would be very bored. And there would be a kid calling out answers before I even asked the

question. So I would shoo them to the side with manipulatives and the [problem].

(second interview)

Problem solving was utilized by Elizabeth as enrichment. In these instances, problem solving provided students with additional time with the content presented in context, while pushing them to explain their thinking and write justifications. Most times Elizabeth's assistant would support the smaller enrichment group so she could continue teaching the whole group lesson.

Elizabeth also incorporated problem solving outside mathematics class in her 30-minute challenge block. During this time each of her students was given a problem that they solved at their own pace using manipulatives. Although students were working independently, Elizabeth was not happy with the way her challenge block ran.

There's a disconnect that I don't have time to figure out. That's been my most challenging thing. When you're talking about word problems and something a bit more challenging the kids freak out. I didn't flush the challenge problems out the way I should have. I should have had a space for a picture, a space for an equation, and a space for a formula. I always tell them that there's multiple ways to think about problems, but you always have to be able to explain what you did and how you got the right answer. (second interview)

Elizabeth views her current teaching of problem solving in a different context than the version she previously defined. "I teach problem solving in the sense of I always try to have a picture, or an equation, or manipulatives. Kids have to explain it and I badger them to get the explanations" (second interview). When describing her own

teaching, Elizabeth used air quotes. “I don’t actually know that what I’m doing counts as problem solving. I don’t believe it’s detrimental to kids, but it’s what I’ve made problem solving out to be in my mind” (second interview).

Perceptions of good problems. Elizabeth determined good problems by both their content and structure. A good problem was one that challenged her or was beyond her own understanding. Problems that involved fractions, decimals and conversions were also identified as good problems due to their perceived difficulty to an upper-grade student. Good problems were typically word problems that provided a context and required background knowledge to solve. Problems that were perceived as ‘good’ incorporated multiple steps, had distractors, used a variety of operations, were open-ended and included an explanation.

Kerri: A focus on process. Although, Kerri ended her first year of teaching with several success that she attributed to problem solving, she began her second-year not implementing those practices. With the incorporation of the new CCSSM (NGACBP & CCSSO, 2010), Kerri felt like a first-year teacher once again. Kerri viewed the change in standards as a positive one that would ultimately lead to an increase in students’ mathematical understanding. Prior to the CCSSM, the standards were not nearly as deep as they needed to be.

I also really believe that teachers didn’t have the proper training to fully get into it. The [content] was brushed over so fast because there were so many standards for the kids to learn. Before the Common Core, I had 43 standards to teach my

kids in math. Forty-three!! And one standard was add, subtract, multiply and divide decimals. That's 64 skills in actuality. (first interview)

Even though the number of standards was reduced, Kerri felt that the content knowledge now required of students was so deep that the complexity increased.

Kerri believed that Common Core math was hard. She also believed that her students would eventually become successful with the content despite their gaps in knowledge. To help her students fill their knowledge gaps, Kerri did not go all the way back to the basics. "The students are coming in with misconceptions from their previous teachers, because the teachers haven't even taught it to them with understanding" (second interview). To support her students with where they were at, Kerri focused on the skills that she predicted her students would struggle with the most. Beginning at the concrete, she built a solid foundation for her students before moving to the abstract. However, halfway through the school year, Kerri realized that breaking down the standard and using the gradual release model to move from the concrete to abstract was not enough.

I was taught as a kid that the definition of crazy is doing the same thing over and over and expecting a different result. Half of this year I did the same thing where I was like they got it! They failed. They got it! They failed. I [realized] something was missing. It was that I wasn't teaching them to think. (second interview)

Kerri realized that she had only taught her students a process which did not work. Once Kerri incorporated problem solving into her teaching both her instruction and her students' performance improved.

The standards for mathematical practice (NGACBP & CCSSO, 2010) are purposefully intertwined in Kerri's instruction. Kerri loves the real-world connections that are encouraged. The connections were easier for Kerri to make and explain as she became comfortable with her content. "Kids need to see the connections to the real-world. They need to see math in art. They need to tie in math to history and language arts" (second interview). Whenever she had the opportunity, Kerri made mathematics interdisciplinary. Once, her students were in charge of making a memorial garden to commemorate those lost in the holocaust. She created problems centered on paintball courses and cheerleading to both connect to the real world and engage her students.

Kids learn best if they are engaged and can find an access point. They need to see a connection, a reason, for learning their content. And then they can feel successful. They may not get the whole thing, but they have become better mathematicians for getting that piece of it. (second interview)

To create student engagement, Kerri also incorporated her students' strengths into her mathematics teaching. Their love of the arts encouraged Kerri to incorporate songs, dance and artwork into mathematics. Kerri strived to change her students' attitudes and get them to love math.

Another mathematical practice Kerri emphasized in her instruction was the importance of communicating by using mathematics vocabulary accurately. Kerri wanted students to understand what they were talking about and not just parrot a term. Kerri purposefully planned for the use of vocabulary in her lessons and treated the language of mathematics as a secret code that allowed entry into a "math-culty" society. Demanding

that her students utilized the vocabulary correctly also assisted Kerri with developing confidence in her own mathematics ability; she now knew the meaning behind many of the words she had not previously known.

To Kerri, learning the CCSSM (NGACBP & CCSSO, 2010) was achieved through student conversations and teacher questioning. Students and questions were purposefully paired in each of Kerri's lessons. Her ultimate goal was to provide each student with an opportunity to answer high-level thinking questions at the access point they were ready for.

I wanted them to do the sharing, to have the conversation. I didn't want it to come from me. I got more and more confident as a teacher to allow that to happen and steer the conversation instead of leading it. (second interview)

Kerri wanted her students to push one another and 'be little mini-teachers.' She wanted them to achieve success with the CCSSM and further their own understanding of mathematics through discussions with peers. Although difficult, Kerri held off immediately intervening in student conversations because she believed her students would come to the greater understanding given the opportunity. Kerri believed she was not the knowledge-holder of the class. Often Kerri would play devil's advocate to rile up her students and make them think. "They love telling the teacher that she's wrong. The engagement is amazing" (second interview). Kerri's mathematics block always filled the mandated time because she valued it. "Ninety minutes because I have always cared more about math. It's my baby" (first interview). Kerri not only placed an emphasis on the Mathematical Practices, she also placed an emphasis on student understanding. In

planning her lessons, Kerri began to place the deep learning first, something she had not done prior to the implementation of the CCSSM. Teaching the algorithm was “an effective way to get an answer, but you weren’t showing me you really understood dividing fractions. You’re showing me you understand step one, step two, step three” (second interview).

Kerri did not feel limited by the CCSSM (NGACBP & CCSSO, 2010). In fact, the new standards provided her with a good guide for the year. “Common Core math is hard, but I can see why kids would need to know it. Explaining to the kids why we do something is huge. So are solving problems in multiple ways” (first interview). Students in Kerri’s class earned extra points for perseverance by finding more than two ways. Often, Kerri challenged her students to find four or five. “I’m so glad they’re focusing on the [attitudes] now. Before math was ‘Can you add?’ not, ‘Can you do it with a little perseverance when it gets hard?’ (second interview).

Kerri recognized that the CCSSM (NGACBP & CCSSO, 2010) demanded a lot from kids. “That’s why I try and teach math the way I do. With as much conceptual understanding as I can. I’m still not great at it, but I’m working towards it” (first interview). However, it is her own struggles as a learner of mathematics that made her want to really want to know the content. Kerri needed much more familiarity with the content in order to teach it at the depth and level of understanding that the CCSSM required. As the only teacher responsible for her grade-level at her school, there was no one to support her with content. She learned her content this year by watching online videos and reading her Van de Walle (2010) textbook from her mathematics methods

course. Kerri especially loved the intensity and thoroughness of the Van de Walle (2010) book. “It really showed the verticalness and the connections between grade-level curriculum” (first interview). It was the presentation of the vertical curriculum that allowed her to support her learners at differentiated levels.

You need to teach kids all the different ways. I was only taught one way and as I got to higher math that way didn’t work anymore. I floundered. My kids who were only taught one way of math, which was memorization for many years, when that doesn’t work anymore, or maybe it never worked for you, and now you don’t understand your multiplication [at this point], that’s a really big problem. They don’t understand that multiplication is multiple groups or equal groupings. They don’t understand that division is like partitioning into two. It blew their minds and they’ve been doing division for two-and-a-half, three years. (first interview)

Knowing different ways also assisted her to know her content deeper than just the algorithms and shortcuts.

As a teacher I have been more a learner of mathematics than I was as a kid. Having to learn as many ways possible so that there is a way to connect with each kid really makes you know your content. If I had been taught like this as a kid it would have been awesome. (second interview)

Re-learning the content helped Kerri make sense of the mathematics she was responsible for teaching. At the end of her second-year of teaching, Kerri admittedly does not fully understand the CCSSM. However, her anxiety no longer paralyzes her. “The gauntlet has

been thrown. Now it's like, you can do this. You just need to learn your content. I know I can teach it, but I want to teach it to a much deeper level" (first interview).

Problem solving for all. When asked to define problem solving, Kerri gave the following description:

The children, students or adults in the room are presented with a problem or task to figure out. They either already have experience with the skills they need to solve it, or it can be used as a type of fishing [to find out] who knows what, and how many different ways can we solve it. At the end there is a sharing out process where you are able to discuss the many different strategies. To me the whole point is to teach children how to think and that there is not one way to go at a problem. It really is a way to connect back to life because when you walk into a supermarket and you're trying to figure out if you have enough money there are ten different ways to figure it out. We're not all going to use pen and paper. We're not all going to estimate. We're not all going to draw a picture. [Those are] life problems. (first interview)

Kerri's understanding of problem solving stemmed from both her elementary mathematics methods course and her school's emphasis on problem solving during her second year of teaching. The incorporation of problem solving was a district goal and Kerri's school took additional steps to ensure its implementation. Every six to eight weeks, teachers at Kerri's school focused deeply on one aspect of a three-part problem solving cycle: (1) the warm-up; (2) the students actively working on the problem; and (3) the sharing of student solutions. Her school's instructional coach monitored Kerri's

progress with problem solving. For each part of the cycle the instructional coach awarded MVPs to teachers who did an outstanding job in the identified area. Kerri won the first MVP due to her excitement about implementing problem solving.

I think that [my math methods course] lit the fire. Between math methods planting those seeds and then this year with our training that we've been going through, I think they just gelled so perfectly together. I'm seeing these connections now where math is so much like a Socratic Seminar. Here's our problem, let's talk about it. What do we see? What are the different inroads? Without that math methods course I'd think that these people are crazy. (first interview)

Kerri was so emphatic that problem solving was the best way for her students to successfully access the CCSSM (NGACBP & CCSSO, 2010), she went above the required minimum and incorporated problem solving at least two to three times each week.

For each problem Kerri's students had to identify at least two ways to solve the problem. Students were also expected to provide a written explanation, something that was difficult across the subjects for her students. As students shared their methods, Kerri created strategy posters that would later be displayed around the classroom. As she became more comfortable with her school's problem solving format, Kerri also became more comfortable with the uncertainty problem solving brought. "A shared confidence in my kids helped me be more confident in letting go" (second interview).

Kerri believed that problem solving allowed her students to own the mathematics content. Prior to beginning a problem, Kerri would brainstorm a list of strategies with her

students. Even if a student suggested a method that was not appropriate for the problem, Kerri recorded it. “Students need to be able to test out their ideas to see if they work and determine the reasonability of what they said. If I tell them [it won’t work], they may not get it. They need to see it” (second interview). Allowing students to come up with their own methods gave her students the creative space to think about and explore mathematics.

To assist with decreasing frustration and increasing confidence Kerri often frontloaded her problem solving lessons the day before with the content required.

I knew I had to change attitudes first. They had to feel confident they knew how to multiply fractions before we got into problem solving. But I think after a couple of years of understanding [the Common Core] way of learning kids will be much more able to do this. I just don’t think I’m confident as a teacher yet to do that. (first interview)

At the end of her second-year of teaching, Kerri admitted she does not fully understand the CCSSM (NGACBP & CCSSO, 2010). However, she felt confident in her ability to make any of the CCSSM into a problem solving lesson.

Perceptions of good problems. Kerri made up most of her problems. After searching online, she often found that the problems she identified did not have nearly enough rigor. Kerri then placed the problems into a real-world context in order to engage students and motivate them. Kerri considered good problems to be problems that encouraged communication, promoted connections to the real-world, allowed modeling,

and promoted the use of manipulatives. Differentiation was provided by adjusting the numbers within the problem for each group.

District assessments and the CCSSM. Both teachers felt that the frequency and difficulty of assessments were ‘ridiculous’ and ‘extremely rigorous.’ However, the impact that district assessments had was different for each. Elizabeth believed that the mathematics assessments were too rigorous, and needed to be toned down for her students. Kerri believed that through the process of constant problem solving her students would have success with the district assessments.

Elizabeth: Assessment drives instruction. Often, Elizabeth used the district assessment questions as guides for her warm-ups. The questions from the district assessments were mostly multi-step word problems that contained multiple distractors. Elizabeth found the pacing of the assessments to be misaligned with the developmental growth in her students. The pacing of the assessments frequently forced Elizabeth to move on to the next standard, even if only a small percentage of her students understood or mastered the material. “Obviously if only 15% of the class got the concept I hated moving on to the next standard. I only did that when we were coming up to an exam” (second interview). In this manner the pacing of the district assessments drove her instructional pacing.

It was a little exhaustive because you’re always feeling like you’re teaching to the next test. And you are. One of my soapbox issues is that I feel we’re taking the fun out of learning because of the degree of assessments (third interview).

Elizabeth felt that although the assessments were extremely rigorous and took mathematics instruction to the next level, they could be toned down. Due to the implementation of the CCSSM (NGACBP & CCSSO, 2010), there was an increase in the amount of word problems on the district assessment that frustrated Elizabeth. “I hate planning for word problems. Probably because I am not confident in teaching that, or really knowing it myself” (second interview). Additionally, district assessment questions often differed from traditional instruction. For example, the assessment would ask students to identify a story problem that matched a given equation. Many of these concepts were new to both Elizabeth and her students. Although her students struggled on the assessments, Elizabeth attributed a part of their struggles on the newness of both the CCSSM and the aligned assessments. “In three or four years if you give the kids who have been exposed to these questions all along, the average will be higher” (second interview).

Kerri: A necessary evil. Kerri felt that district assessments were becoming harder and more open-ended. Both of which supported her idea of moving away from multiple-choice questions and towards problem solving. However, Kerri struggled with making the connection from problem solving instruction to multiple-choice assessments. Her students showed a great amount of success on problems and tasks as determined by a rubric over the course of the year. However, on multiple-choice assessments their success was not as obvious.

Her first-year of teaching, Kerri only used multiple-choice questions to review for the district assessments. The constant review of multiple-choice was “dreadful for all

involved. It wasn't engaging. There was no purpose. It wasn't real-world" (second interview). Her second year of teaching Kerri used problem solving as a way to review for the year-end assessments, "because life is full of problems that you might not recognize" (second interview). Kerri's students had a hard time making the connection between showing their strategies and multiple choice questions. "I never made it clear enough how to take a multiple choice test. I wanted to see at least two strategies for every problem and [when taking their assessment] kids asked 'Can we use our strategies on our test too?'" (first interview). Kerri believed that she needed to make a better connection demonstrating how the strategies her students used for problem solving could also be used to take assessments. Multiple-choice assessments were 'a necessary evil,' as they were a part of teaching that was not going to go away.

Beliefs in Impacting Students

As teachers in the lowest performing elementary schools in their district, the expectations and pressure for all students to academically succeed was great. Many factors influenced Elizabeth and Kerri's abilities to meet their students' learning needs. Some of the factors such as scaffolding experiences were within their control. Other factors such as available resources and parental involvement were not. Both teachers believed they could impact their students. However, the student segments they impacted differed. Elizabeth focused on a specific segment of the classroom population, whereas Kerri focused on the class population as a whole.

Elizabeth: Impacting students I can reach. Elizabeth did not believe she had the resources to make the impact that was needed. Her students were so far behind. “I do [enjoy teaching math]. I just find with my really low guys I don’t know what to do with them. I don’t enjoy teaching math to them because I feel like they never get it” (second interview). Another frustration was with the lack of parental support. Elizabeth viewed parental support as an essential element to student success. Without parental involvement students could not reach their full potential.

I understand their parents aren’t involved. I understand this and that. But [these kids] still have the ability to learn to a certain degree. Even if it’s not the level that a very supported child in a very rich neighborhood would get (first interview). Elizabeth also became frustrated with students who were not willing to work for their academic success. “If you’re going to give up this easily, I’m going to help someone who’s not. Someone who has been struggling but hasn’t pushed the worksheet off the table” (first interview). Remaining patient was the primary challenge Elizabeth faced when working with her struggling students. “How do I stay patient or give those kids the help they need? They need so much more. If I give them more of my time I feel like I can’t make a dent in their void” (first interview).

During Elizabeth’s first year of teaching she had students who regularly stayed after school and called her on her cell phone for help. That was not the case for her second year of teaching and Elizabeth was frustrated with her struggling students’ unwillingness to advocate for help. Elizabeth believed if her students were willing to give up their time and sit with her then they would learn the content. However, she was not

going to help them if they were not willing to help themselves. Elizabeth reflected on her unwillingness to advocate for students who were not advocating for themselves.

If they aren't going to attempt the homework, if they aren't going to attempt the problem, if they aren't going to attempt to call me...If you ask for my help during specials it's going to be very quick help. Part of that is I'm busy obviously. But part of it is if you're not putting in the effort in for me to feel like you're going to match it. With other students I genuinely try and put more time in because they're putting in more time and asking really provocative questions. Some of which I can't answer. I appreciate that so I'm going to give them more of my time. (first interview)

Unsure how she could support her students who did not either comprehend math or advocate for themselves, Elizabeth focused her time on those that she could impact and she believed had potential for growth. At the end of Elizabeth's second year there was one student, Christine, who was getting extension problems beyond the grade-level curriculum.

This girl she blows my mind. She struggles at first and grumbles, 'Oh you're making me do too much!' But then she gets it and she's ready for the next step. I really wish I was able to think outside the box more [for her]. I should have done that throughout the whole year, not just at the end. (first interview)

Kerri: Impacting all. Throughout the school year Kerri connected with her students in different ways. However, she was intrigued by the students that shared the strong dislike, even hatred, of math that she had at that age.

I totally understand where those kids come from. The first day of class I tell them the story of me as a kid. I share the story of me with math, so frustrated in tenth grade that I wrote 'go to Home Depot' on my test. The kids always laugh and I tell them I understand if you don't like math. I understand where you're coming from. I always try to reassure them that it's my job to teach you until you understand. If you don't understand, you better keep telling me you don't understand. (first interview)

As a result, Kerri channels Mr. Pollock a lot. She constantly asks her kids what it is about the problem that they don't get. Student responses of 'I don't get it,' is not enough. Kerri helps to scaffold their understanding of their misconceptions by teaching them to ask the right questions. In doing so, she also builds their confidence. Kerri's goal is to help her students find that one specific aspect of mathematics they are struggling with so that they can later say they are good at mathematics. She wants all of her students to love math.

Kerri believes that her students should be able to master their mathematics content. She structures her routines to incorporate multiple opportunities for think time, both independently and collaboratively. The expectations were that her kids tried. They needed to put something down that showed effort and made sense.

I want my kids to be thinkers. Plain and simple. I want my kids to know how to think and think their way out of a paper bag. I want them to think of multiple ways to solve a problem. The shift that was forced on me, but happily made, is what will ultimately get my kids there. (first interview)

Longevity In Teaching

TFA requires participants to stay in teaching for two years. At the end of their second-year of teaching, Elizabeth and Kerri are now certified teachers who possess a master's in education. Both believe that the traditional TFA experience of "in-and-out in two" is not as prominent as it once was. Many of their peers decided to stay in teaching; which was not the norm. Elizabeth entered TFA to buy herself time. Kerri joined because she believed she was a lifelong teacher. Both wanted to stay in their current location. Having reached the end of their two-year commitment, the time had come for Elizabeth and Kerri to determine what the next year would bring.

Elizabeth. When asked if she plans to continue teaching, Elizabeth responds, that her school is closing, which presents her with an unusual opportunity. "This is the perfect bow out opportunity. We're closing. I don't have to tell anyone why I'm leaving" (second interview). However, Elizabeth's principal found her a job at another elementary school in the district and she felt like she could not say no. Even though all her students made academic gains, Elizabeth felt as if she did not do enough to foster their growth.

I admit that some kids will think I was a detriment. But I truly hope that I get to be that meaningful person to someone. To be someone that they remember. A couple of years ago that wouldn't have mattered to me at all" (third interview).

Elizabeth hopes that there will be less stress her third year; especially since she would not be teaching mathematics. “A part of me feels anxious. Am I digging myself into a grave? Am I putting too much into education to where I can’t get out?” (second interview). Elizabeth does not know if she is ready to quit. She kind of enjoyed teaching, but she hated it at the same time.

A part of her is nervous about continuing with education. Right now Elizabeth’s parents have offered their financial support for the next six months if Elizabeth stops teaching and chooses to look for a job in national security and intelligence. However, teaching full-time and earning both her certification and a master’s has left little time for her original course of study.

Again, I haven’t given any time or thought to my other master’s so the thought is that the third year I won’t have any [grad] school. I’ll be able to legitimately go to the events, take another course, or something. I might buy myself one more year.
(third interview)

When asked if she would do this again, Elizabeth responded that she thinks she would, but she is not sure. Over the last two years she has realized that “teachers cannot just come in and change things. It takes so much work” (second interview).

Kerri. Kerri believes that teaching is the most complicated thing one could ever do. Next year, Kerri will be leaving the school district that currently employs her to work at a nearby charter school. She will be teaching the same grade again; however, next year Kerri will only be responsible for teaching mathematics. Kerri is looking forward to teaching one subject and getting good at “really learning thirty different ways to teach [mathematics]” (second interview). She is both nervous and scared of her next steps at the neighboring charter because of the high expectations. However, the challenge of teaching a similar population with more resources and collaboration also excites her, “It’s going to require a lot of deep thinking” (third interview). She wants to teach the meaning before the algorithm, and is excited about the opportunity to become a better teacher.

Kerri entered TFA with the intent to ‘stay teaching.’ She has since become a lifelong teacher and pictures herself in education for the next ten to fifteen years. She believes it will take that long for her to become good. Eventually Kerri wants to have a specialization, which she admitted would probably be in mathematics.

Conclusions

Although similar, there were several differences in the problem solving beliefs and perceptions Elizabeth and Kerri held. Sacrificing her time and following steps relieved Elizabeth’s mathematics anxiety, while developing conceptual understanding relieved Kerri’s mathematics anxiety. At times, that meant Kerri had to demand a more accessible way to the content from her teachers. Both joined TFA at the conclusions of their master’s programs. However, Elizabeth perceived TFA as a name brand that would boost her resume, while Kerri knew she was going to be a lifelong teacher. In the

elementary mathematics methods course both women were exposed to problem solving. Elizabeth knew she was not ready for that type of instruction. After constant pushing from her instructor, Kerri finally tried problem solving with her students and immediately saw the benefits and value. With the incorporation of the CCSSM (NGACBP & CCSSO, 2010) both Elizabeth and Kerri had to learn a new set of standards. During this time, Elizabeth emphasized the rigorous content and believed that students had to demonstrate mastery prior to problem solving. Kerri emphasized teaching the content through problem solving and the standards for mathematical practice (NGACBP & CCSSO, 2010), and believed all of her students were capable. Despite the similarities of many of their experiences, Elizabeth and Kerri viewed problem solving differently. Elizabeth viewed problem solving as something that was hindered by the CCSSM, while Kerri viewed problem solving as the only way to teach the CCSSM. These differences in beliefs and perceptions influenced their view of problem solving greatly.

Chapter Five

The purpose of this study was to better understand the problem solving beliefs and perceptions of second-year teachers in a TFA cohort. To accomplish this goal a qualitative case study was utilized to answer the following questions:

1. In what ways do personal and academic background influence the problem solving beliefs and perceptions of second-year teachers in a TFA cohort?
2. In what ways do the elementary mathematics methods course influence the problem solving beliefs and perceptions of second-year teachers in a TFA cohort?
3. In what ways do the implementation of the CCSSM influence the problem solving beliefs and perceptions of second-year teachers in a TFA cohort?

Two individuals from a TFA cohort were identified by their elementary mathematics methods instructors as individuals who “got” problem solving. The participants were then interviewed multiple times to determine if and how the experiences in different facets of their lives influenced their beliefs and perceptions of problem solving. This chapter summarizes the findings for each research question, presents the conclusions as they pertain to the current literature, and discusses the implications for research and mathematics teacher education.

Research Question 1

The personal and academic backgrounds of Elizabeth and Kerri influenced their beliefs and perceptions of problem solving. Despite the fact that their backgrounds were similar in many ways, the influence on their problem solving beliefs and perceptions differed. However, there are two common elements that influenced Elizabeth and Kerri: (1) their experiences with achieving success in mathematics; and (2) their perceived longevity in education.

Through the belief that students learn mathematics best through a series of steps, Elizabeth never really believed that problem solving would work for her students. Elizabeth also expected her students to sacrifice their time in order to learn mathematics. As a result, students who did not sacrifice their time struggled with the content and were never able to be a part of the challenge group that problem solved. Kerri's belief that students learn best through asking questions, developing a conceptual understanding and making connections to the real world, aligned with the use of problem solving in her classroom. Kerri also believed that her job as a teacher was to ensure that every student learned the content. Through both teaching her students how to learn and making connections through the context of problems Kerri taught problem solving. In these instances, Elizabeth and Kerri's beliefs in how students succeed in mathematics mirrored their own and influenced their beliefs and perceptions of problem solving.

Elizabeth and Kerri's perceived longevity in education also influenced their problem solving beliefs and perceptions. Elizabeth entered teaching to boost her resume and gain entrance into a different field. Recognizing that she was not going to be a

teacher forever, Elizabeth had no reason to struggle with her pre-existing beliefs and perceptions to incorporate problem solving: a practice that was both unfamiliar and uncomfortable. In comparison, Kerri pictured herself staying in teaching for at least 10 years. Incorporating problem solving into her previously held beliefs was important for the longevity of her newfound career. Each participant's beliefs in their longevity of teaching inadvertently influenced their beliefs and perceptions of problem solving.

Research Question 2

The elementary mathematics methods course influenced the problem solving beliefs and perceptions of both Elizabeth and Kerri. However, their influence differed in two ways: (1) the manner in which their anxiety allowed them to access the content; and (2) the way each engaged with weekly problem solving opportunities.

Both Elizabeth and Kerri had anxiety towards learning and teaching elementary mathematics that stemmed from years of struggling with the content. However, Elizabeth and Kerri felt that the elementary mathematics methods course was a safe place to learn. Their professor, Dr. Stephens, provided the necessary support, and assisted both women with building their confidence. Although Elizabeth and Kerri's anxiety levels decreased, the anxiety that remained influenced their interactions with the elementary mathematics methods course, and as a result their beliefs and perceptions of problem solving.

Elizabeth's anxiety stemmed from not knowing if solutions were accurate and led her to overgeneralize in ways that were not conducive to problem solving. Kerri's anxiety stemmed from not knowing her content deep enough and forced her to learn her content

to the point where she could comfortably allow students multiple entry points into a problem solving lesson.

During their weekly problem solving sessions Elizabeth and Kerri were pushed outside of their comfort zones. Initially both Elizabeth and Kerri stuck to the method of problem solving that they were most comfortable with, the traditional algorithm. Often as peers presented alternate strategies Elizabeth was confused and tuned her peers out. Even though Kerri often did not understand how her peers came to their solutions, she was intrigued and listened attentively.

Elizabeth and Kerri's exposure to problem solving helped to foster the belief that problem solving in elementary grades was beneficial. Neither Elizabeth nor Kerri initially believed that problem solving would benefit their students. Kerri constantly pushed back until Dr. Stephens finally convinced Kerri to try problem solving with a small group of students. Once Kerri did, she realized her students were capable of deeply thinking about mathematics.

Research Question 3

The CCSSM (NGACBP & CCSSO, 2010) influenced the problem solving beliefs and perceptions of both Elizabeth and Kerri. However, the influence primarily differed in two ways: (1) the way in which both women addressed the perceived depth and rigor of the standards; and (2) the way in which their district and schools supported the implementation of the CCSSM.

Although Kerri and Elizabeth both incorporated problem solving in their classrooms, their beliefs regarding the depth and rigor of the CCSSM (NGACBP &

CCSSO, 2010) greatly influenced their perceptions of their students' capability with problem solving. Elizabeth and Kerri both believed that their students did not have the background knowledge to be successful with the CCSSM the first year of implementation. However, how each individual addressed the many holes and gaps in their students' understanding differed.

Elizabeth believed that her students had to master the content before they were able to successfully problem solve. As a result, the lack of student background knowledge and expectations of mastering the content led Elizabeth to believe that problem solving for all students would not work in her classroom. Kerri did everything she could to increase her students' success with the content. Kerri made sure she learned multiple ways to teach the standards, scaffolding her students' experiences to ensure each student had an access point into her lessons. Kerri believed that after an initial exposure, her students would better understand the content through problem solving. As a result, all of Kerri's students experienced problem solving on a regular basis.

The implementation of the CCSSM (NGACBP & CCSSO, 2010) also influenced Elizabeth and Kerri's beliefs and perceptions regarding the identification of problems for mathematics instruction. Both women spent time searching for problems to use in their instruction. Elizabeth believed that her students were unable to access rich problems at high levels of rigor. Elizabeth sought problems at the perceived academic level of her students and often lightened the cognitive demand of problems that she found. However, by lightening the cognitive demand Elizabeth limited her students' problem solving experiences. In contrast, Kerri found that many of the problems she located were not

rigorous enough. She often created her own problems with increased rigor to best meet her students' needs. As a result, Kerri provided her students with increased opportunities of solving rich, rigorous problems during problem solving.

Elizabeth and Kerri's beliefs and perceptions regarding the implementation of the standards for mathematical practice (NGACBP & CCSSO, 2010) were also influenced by the implementation of the CCSSM (NGACBP & CCSSO, 2010). Problem solving is a major element of the standards for mathematical practice. Implementing the mathematical practices was a challenge for Elizabeth. The result of this challenge was an instructional emphasis on the mathematics content and an inability to consistently implement the S standards for mathematical practice. Kerri taught her students through the purposeful use of the standards for mathematical practice. As a result of using the mathematical practices, specifically problem solving, Kerri believed her students were logical thinkers and developed a deep conceptual understanding.

In addition to adopting the CCSSM (NGACBP & CCSSO, 2010), the district that employed Elizabeth and Kerri made several changes that greatly influenced their beliefs and perceptions of problem solving. As a result of adopting the CCSSM, district assessments were modified so that the assessments were aligned with the new standards. Elizabeth and Kerri perceived the problems on the assessments to be non-routine, word problems that elicited a higher level of student understanding than previous assessments. Both women believed that the problems were often situated in context, multi-step and contained distractors. Although Elizabeth and Kerri had different approaches to teaching

the content, both viewed the assessment to be extremely rigorous and incorporated similar problems in their teaching.

With the implementation of the CCSSM (NGACBP & CCSSO, 2010), the district Elizabeth and Kerri worked in provided many supports. In addition to increased resources within each of their classrooms, Elizabeth and Kerri also attended district professional development that discussed the implementation of problem solving. While the message regarding problem solving was consistent at the district-level, the incorporation of problem solving looked different at each of their schools. Elizabeth never discussed problem solving as a push from her school. Additionally, no evidence was provided by Elizabeth that showed she received any support or guidance from her school with implementing problem solving. Kerri, however, worked at a location that had a school-wide push for problem solving. She also received the support of an instructional coach. As a result of the emphasis by their schools, Elizabeth had no support or guidance in implementing problem solving while it was expected that Kerri would.

Implications for Research and Mathematics Teacher Education

This study explored the beliefs and perceptions that influenced novice elementary teachers' problem solving. Specifically, I wanted to better understand how the different facets of novice teachers' lives influenced their problem solving beliefs and perceptions. In the previous chapter the findings were presented for this study. This chapter summarized the results for each research question and presented the conclusions. The following section describes the implications of this study on future research and mathematics teacher education.

Implications of research. Due to the recent implementation of the CCSSM (only three years prior to this study), little research exists on its implementation and virtually no research exists on the use of problem solving to teach the CCSSM and standards for mathematical practice (NGACBP & CCSSO, 2010). Much of the previous research on problem solving within the elementary mathematics methods courses dealt with the initial incorporation of the NCTM (2000) standards. While research has been conducted on alternate licensure programs, such as TFA, much of the research placed an emphasis on teacher attrition and effectiveness (Darling-Hammond, et al., 2001; Darling-Hammond et al., 2005; Gardner, 2008; Glazerman, 2006). The lack of current research has many implications for the future. Three ways in which future research has the ability to extend current research are as follows: (1) determining the connection between problem solving and teacher evaluations based on performance; (2) the identification of the perceived longevity of teacher candidates; and (3) additional in-depth studies of individuals as they transition into the classroom.

Problem solving and teacher evaluations. The area of teaching the CCSSM (NGACBP & CCSSO, 2010) and standards for mathematical practice (NGACBP & CCSSO, 2010) through problem solving is new and needs to be explored. Previous problem solving research did not involve a national set of mathematics standards that was implemented in all but a few states. With the incorporation of rigorous high-stakes assessments that promote critical thinking, the future of problem solving research differs from that that was conducted when assessments tested minimum competency levels. Additionally teacher performance evaluations are now tied in to state assessments. With a

set of mathematics standards adopted by multiple states that promotes problem solving, researchers need to identify if teachers are prepared to embrace problem solving while under evaluation. If not, research needs to identify the required support. The knowledge gained from this research could potentially change the way problem solving is implemented and perceived by teachers.

Perceived longevity of teacher candidates. With the incorporation of alternate licensure programs that have a quick turnover, a deeper examination is needed to determine how individuals are identified for teacher licensure programs and their motivations for entering them; specifically to determine the longevity of individuals within the profession. Identifying the reasons for an individual's entrance into teaching is essential; especially since long-term certification routes are not what people want anymore (Koerner et al., 2008). While some individuals seek alternate licensure routes to become lifelong teachers, others are entering teaching programs to either boost their resume or gain access into another field. In the instances of both Elizabeth and Kerri the reasons for their entry into teaching influenced their problem solving beliefs and perceptions. Both participants were well-educated and already possessed master's degrees as they entered their teaching certification program. They participated in an elite program that has a highly selective screening process. Additionally, these individuals were identified for this research based on their instructor's perception of their problem solving abilities and beliefs. Out of an entire cohort of highly qualified candidates, I perceived these two individuals to be the most likely to incorporate problem solving as defined by the NCTM into their beliefs and practices. However, coming into their teacher

certification program one of the two participants did not expect to stay in teaching. Without the intent to stay in teaching, there was little reason for her to step out of her comfort zone and try to incorporate a practice that was both unfamiliar and uncomfortable. Research needs to be done on how to identify individuals that plan to stay in teaching and are willing to change their beliefs. Beliefs are already known to be resilient and difficult to change (Ambrose, 2004; Foss & Kleinsasser, 2001; Guskey, 1986; Raymond, 1997; Rolka, et al., 2009; Sakshaug & Wohlhuter, 2010; Schilling-Traina & Stylianides, 2013; Warfield et al., 2015). Identifying individuals who are aware of the impact of their longevity in teaching is essential if they are to recognize the importance of addressing their beliefs and incorporating practices such as problem solving.

Transitioning into the classroom. Current research isolates pre-service teachers and in-service teachers as participants. More research is needed that explores the transition that occurs as individuals progress from their elementary mathematics methods courses into their first-years of teaching. Future research could explore the stories of individuals who were able to successfully overcome the barriers from their past and incorporate foreign practices. While these lessons are not always generalizable, there is a high level of transferability. In the case of Kerri, even though she struggled with learning mathematics all her life and developed a deep hatred of the subject, she was able to overcome her negative feelings through a series of events that combined her personal, academic and professional experiences. Understanding similar transformations can only better teacher education programs and professional development opportunities.

Implications for mathematics teacher education. There are many implications of this research for mathematics teacher education. The primary ways in which this research study can inform mathematics teacher education are listed as follows: (1) continued exposure to problem solving and non-routine problems; (2) the purposeful planning of the standards for mathematical practice; (3) the utilization of problem solving as an introduction to content; (4) the need for more than one elementary mathematics methods course; (5) professional development on the CCSSM; and (6) the alignment of professional development at all levels.

Continued exposure to problem solving and non-routine problems. It is extremely important for individuals entering teaching to realize the impact their background has on their instructional practices (Crespo, 2003; LoPresto & Drake, 2004). The pre-existing beliefs that individuals bring with them as they enter into the classroom are difficult to change (Rolka et al., 2006), and old beliefs are resilient and not simply replaced by new beliefs (Ambrose, 2004). Specific exposure to non-routine problems within the elementary mathematics methods course has been found to positively influence problem solving beliefs (Ambrose, 2004; Koray et al., 2008; Wilburne, 2006). It has also been found to help individuals value problem solving (Asman & Markovits, 2009; Ellis et al., 2009), better understand the complexity of elementary mathematics (Ambrose, 2004), and address an inability to think flexibly about problem solving (Ambrose, 2004; Koray et al., 2008).

Neither Elizabeth nor Kerri experienced problem solving growing up. The elementary mathematics methods course was their first experience with problem solving

and influenced their problem solving beliefs and perceptions differently. As research suggests (Ambrose, 2004; Koray et al., 2008; Wilburne, 1997), both women left the course believing that problem solving was beneficial. However, Elizabeth also left believing that neither her nor her students were ready for problem solving. Perhaps the problem solving beliefs of Elizabeth would have differed if she had been more engaged during the sharing of student solutions. In contrast, Kerri, who engaged in her peers' solutions, left the elementary mathematics methods course believing that problem solving was beneficial and valuable to all students. Additional research is needed to determine the influence that the level of engagement has on an individual's problem solving beliefs and perceptions.

Previous research also found that individuals in elementary mathematics methods courses valued non-routine problems less than traditional problems (Lee & Kim; 2005). However, this was not the case for Elizabeth and Kerri and was most likely the result of new assessments with increased rigor and exposure to non-routine problems. Since both women were using district assessment to guide their instruction, they both attempted to incorporate open-ended problems with multiple access points and explanations as that was the new demand placed on them. However, while both teachers valued non-routine problems, Elizabeth believed the problems were often too difficult and inaccessible for her students. This aligns with previous research that found when faced with identifying problem solving tasks for students, teachers have previously been known to lighten the cognitive load of the problem (Parks, 2004). One reason for this was most likely due to Elizabeth's discomfort with the content. However, Kerri believed that with the right

scaffolding her students could achieve. As a result, Kerri believed that she increased the rigor of her problems on a regular basis. This contradicts previous research (Lee & Kim, 2005; Parks 2004). More research is needed that looks into this phenomenon if novice teachers are to be successful with implementing a rigorous set of standards such as the CCSSM.

Purposeful planning of the standards for mathematical practice. As a result of this study, a next step for research is to explore the implementation of the standards for mathematical practice (NGACBP & CCSSO, 2010). The teachers in this study were both from an alternative licensure program that included a course that emphasized the teaching of elementary mathematics through problem solving. One teacher internalized that the CCSSM (NGACBP & CCSSO, 2010) hindered problem solving while the other saw problem solving and the CCSSM as inseparable. To teach the CCSSM with fidelity, individuals need to truly understand not only the content embedded in the standards, but the standards for mathematical practice as well. Purposefully planning the incorporation of the mathematics practices is one way to accomplish this goal, as illustrated by Kerri. Purposeful planning would provide pre-service teachers a specific way to incorporate the practices that would benefit their teaching and the students involved. It is also a practice that would benefit them as they prepare to enter into the elementary classroom.

Problem solving as an introduction. The belief that problem solving comes after learning content or being exposed to content still prevails. Despite a national set of standards that clearly defines that learning mathematics comes as a result of exploring the curriculum via contextual problems, neither participant used problem solving to introduce new content. In my own practice I have experienced the value of problem solving as an exploration to new content. When done this way students are afforded the opportunity to explore unfamiliar content while accessing their background knowledge, applying previously learned content and making hypothesis and generalizations. Problem solving is a powerful practice that benefits both teachers and students. It is a practice that can be utilized in many ways. In order for individuals to come to this understanding they must experience it first hand. Incorporating these experiences into the elementary mathematics methods course would support and encourage the growth of this practice.

The need for more than one methods course. Mathematical problem solving is foreign to many individuals. Traditionally problem solving was taught as word problems presented at the end of a unit. An individual's first exposure to problem solving as defined by the NCTM (2000) and expected by the CCSSM (NGACBP & CCSSO, 2010) is often in the elementary mathematics methods course. While a change in beliefs is possible in the elementary mathematics methods course (Crespo, 2003; Ellis et al., 2009; Guberman & Leikin, 2012), it is not guaranteed (Foss & Kleinsasser, 2001; Schilling-Traina & Stylianideas, 2013). When exposed to problem solving instruction, a teacher may implement only the aspects they are comfortable with as they may perceive problem solving in its entirety too difficult. Other times, an individual may abandon their problem

solving beliefs altogether when facing the day-to-day challenges of teaching. One elementary mathematics methods course is not enough to address one's past experiences, beliefs and anxiety and expect full implementation of modeled practices, such as problem solving. To ensure that problem solving is implemented within elementary classrooms, there is a need for continued opportunities to learn.

Professional development on the CCSSM. Both Elizabeth and Kerri believed that the CCSSM was deeper and more complex than previous mathematics standards. While both believed that the curriculum was deeper than it previously had been, neither Elizabeth nor Kerri were overconfident in their abilities to teach mathematics as research previously suggests (Patton et al., 2008). This may have resulted from the personal struggles each faced learning the content as children in school, and again as teachers. Additionally, research has found that many pre-service teachers perceive their mathematics content to be simple and basic (Lee & Kim; 2005). However, neither Elizabeth or Kerri felt this way about the CCSSM (NGACBP & CCSSO, 2010). This difference between research and practice is most likely a result of the recent implementation of a more rigorous set of standards. The manner in which Elizabeth and Kerri interpreted the more rigorous standards also differed. Due to her discomfort with the standards for mathematical practice (NGACBP & CCSSO, 2010), Elizabeth placed an emphasis on the content standards. However, Kerri emphasized the mathematical practices as a way to teach the content.

There is a need for high quality professional development on the implementation of the CCSSM (NGACBP & CCSSO, 2010) and the standards for mathematical practice.

Specific instruction on problem solving can work (Barlow & Cates, 2006). However, beliefs are grounded in years of experience (Raymond, 1997). Professional development needs to push teachers to provide opportunities to struggle with the mathematics (Schifter & Riddle, 2004). Teachers need to be pushed out of their comfort zone during professional development as the goal is for them to see mathematics as an exploration of ideas, not just a series of steps (Schifter & Riddle, 2004). In this manner more teachers will be able to successfully teach mathematics through the standards of mathematical practice, specifically problem solving.

Alignment of professional development. Since one elementary mathematics methods course is not enough to make sustainable change in teacher beliefs and perceptions a new model needs to be developed. Otherwise we are continuing the cycle of producing teachers who believe either they or their students are not capable of problem solving. A closer look needs to be taken at how we align the elementary mathematics methods course's message of exploring mathematics through problem solving with district and school professional development.

It is essential to align elementary mathematics methods courses with state and district professional development. In this manner both pre-service and in-service teachers would receive a consistent message that aligned their learning experiences. At the end of the elementary mathematics methods course Kerri believed that problem solving was both a valuable and beneficial practice to implement. However, upon returning to her classroom she immediately abandoned problem solving and went back to what was familiar. It was not until her school and district practices aligned with her beliefs gained

from the elementary mathematics methods course that she was able to successfully implement problem solving and internalize a definition of problem solving that aligned with the CCSSM (NGACBP & CCSSO, 2010). With the implementation of the CCSSM, most every elementary mathematics teacher in the United States is responsible for teaching the same mathematics content using clearly defined practices. Aligning the content from the elementary mathematics methods course with district and state professional development can only strengthen teachers' knowledge, increase their exposure to problem solving, and provide them with the support and guidance required to successfully incorporate problem solving into their beliefs.

Closing Thoughts

When conducting this research I broke down the influences of problem solving into three specific categories: academic and personal background, the elementary mathematics methods course, and the CCSSM (NGACBP & CCSSO, 2010). However, throughout my research, all three were highly connected and intertwined with one another. Understanding the influences on education is complicated. We have past experiences and backgrounds that influence us in ways of which we are not always aware. Often, our backgrounds and experiences are as unique as each of us. Yet as a culture we have elementary mathematics methods courses and district professional developments that treat us similarly. A more transitional approach is needed to deeply explore the development of the beliefs and perceptions of elementary mathematics teachers.

Too often the emphasis is on an isolated aspect of teacher education: the elementary mathematic methods course. We try to determine if and how individuals will incorporate practices into their teaching. While we want them to further develop their mathematical understandings and incorporate practices such as problem solving, the reality is that in their first year of teaching they are overwhelmed and focused on survival. In order to address this disconnect a different approach needs to be taken.

What if teacher educators became a mentor that stayed in contact with their students not only through their methods courses, but throughout their first few years of teaching? In this manner, they could continue to provide the support necessary to help with the assimilation of beliefs and practices that are consistent with the successful implementation of problem solving. If we truly want teachers to take up the practices taught to them, something needs to change. Staying with them throughout their initial first years during a time when they are most likely to rely on their previous experiences would provide them with an amazing consistency. A consistency that could not only support their growth in essential practices, but change our profession as well.

APPENDICES

Appendix A: Interview #1 Protocol

1. I'd like to start with your early experiences as math student. As a child, how did you feel about doing and learning math?
 - a. Prompts: classroom-experience during elementary school, think of a teacher,
2. What was learning math like for you?
 - a. Prompts: classroom environment
3. Tell me about an experience as a learner of mathematics?
 - a. Prompts: how did you feel, where was it? what happened?
4. Think back to your undergraduate work and tell me about your math methods course.
 - a. Prompts: planning and developing lessons, projects, field work, manipulative use, problem solving, open-ended
5. How did you feel about learning math as an adult?
 - a. Prompts: success, anxiety, confidence
6. Now, I'd like to ask you about being a math teacher. Talk to me about your mathematics teaching this year.
 - a. Prompts: successes, difficulties, challenges
 - b. Prompts: planning, lesson development, problem solving, open-ended questions, representations, manipulatives, type of instruction
7. How did the information provided from your methods course come into play during this time?
 - a. Prompts: textbook, lessons, materials, resources
8. Talk to me about your decision to become a teacher.
9. Now that you have been teaching for a year, what information do you wish you had known before starting?
10. Is there anything else about your math teaching that I have not asked you that you want to share?

Appendix B: Interview #2 Protocol

1. How do you feel about learning mathematics? How do you feel about teaching mathematics?
2. Describe your mathematics class.
 - a. Prompts: What are the students doing? What is the teacher doing? What type of work is being done?
3. How do you plan for teaching mathematics?
 - a. Prompts: Does anyone help you? What materials do you use? Do you plan at home or at school? Do you enjoy teaching math? Do you enjoy planning math? How much time do you spend preparing for math? Are you comfortable teaching math?
4. How do children learn mathematics best?
 - a. Prompts: actively involved, textbook, hands-on, formulas, calculators
5. Tell me about one of your most successful math lessons.
 - a. Prompts: Why do you like the lesson? What went well? What made it successful? What was challenging? What did the students learn? What were the students doing? What were you doing? Can you talk about the mathematics involved?
6. Tell me about a math lesson that you had difficulty with.
 - a. Prompts: Why do you think the lesson was so challenging? How did you feel? What were the students doing? What were you doing? Can you talk about the mathematics involved?
7. What is challenging about teaching mathematics?
 - a. Prompts: Finding resources, being creative, etc.
8. How do you talk about mathematics in your classroom?
 - a. Prompts: Do you explain how to do things? How do the students participate? Groups? Collaborative? Independent?
9. What role do basic facts and computation play in the teaching and learning of mathematics?
 - a. Prompts: rules, formulas,

- b. Do you understand the rules and formulas that you use?
- 10. What role does your textbook play in your mathematics instruction?
- 11. How do you teach problem solving?
 - a. Prompts: Is problem solving a unit? Is problem solving embedded within your teaching? Are there specific strategies that you teach? What are they? Key word, etc. With what frequency do you teach problem solving? What role does problem solving play in your mathematics instruction?
 - b. Prompts: Where do you get your problem solving activities from? Do you make them yourself? Look on-line? Use the textbook?
- 12. What is your reaction to the following statement? The most important part of elementary mathematics is getting the one correct answer.
 - a. Prompts: Is it possible for a problem to have multiple solutions? Why or why not?
- 13. Let's take a look at the following problem: A rabbit is going to hop up a flight of 10 steps. He can only hop up 1 or 2 steps at a time. He never hops down, only up. How many different ways can the rabbit hop up the flight of 10 steps?
 - a. What is your first reaction to the problem?
 - b. What is the problem asking you to find?
 - c. Describe the possible strategies you could use to solve the problem? Why did you pick your particular strategy?
 - d. Describe the process and mathematics used to solve the problem.
 - e. Could you have used another strategy? Was your strategy the most efficient? Does your solution make sense? Why or why not? Are you confident about your solution?
 - f. Present solutions solved by methods course instructors. What do you think of these strategies?
 - g. How do you think that students would solve this problem? Describe how.
 - h. Was this problem a good problem? Why or why not? What would make this problem a good problem?

Appendix C: Interview #3 Protocol

1. Let's look at the ratings of some problems that you gave 4s and 5s to. Can you explain your justification? Why did you give a _____ (particular rating) to this problem?
 - a. Do you want to change any of your ratings? Why or why not
2. Let's look at the ratings of some problems that you gave 1s and 2s to. Can you explain your justification? Why did you give a _____ (particular rating) to this problem?
 - a. Do you want to change any of your ratings? Why or why not
3. What criteria make a good mathematics problem?
4. How do you use problems in your mathematics teaching?
5. What is the biggest obstacle or concern for you with using problems in your mathematics instruction?
6. Let's take a look at the following problem: Lion cubs were born at the local zoo last week. The zookeeper weighed them two at a time, and got weights of 13, 14, and 15 pounds. How many lion cubs were there and what was the weight of each lion cub to the nearest pound?
 - a. What is your first reaction to the problem?
 - b. What is the problem asking you to find?
 - c. Describe the possible strategies you could use to solve the problem? Why did you pick your particular strategy?
 - d. Describe the process and mathematics used to solve the problem.
 - e. Could you have used another strategy? Was your strategy the most efficient? Does your solution make sense? Why or why not? Are you confident about your solution?
 - f. Present solutions solved by methods course instructors. What do you think of these strategies?
 - g. How do you think that students would solve this problem? Describe how.
 - h. Was this problem a good problem? Why or why not? What would make this problem a good problem?

Appendix D: Good Mathematics Problems Questionnaire

GOOD MATHEMATICS PROBLEMS QUESTIONNAIRE

Please indicate your rating to the left of each instance below and provide your answer for the problem.

1 = Not At All A Good Problem 2 = Somewhat A Good Problem 3 = Undecided 4 = A Good Problem 5 = A Very Good Problem

#	Problem & Your Solution	Rating (1-5)	Explain Your Rating
	Subtract: $95 - 38$		
1			
2	Jerry bought a cake for \$10. It's $\frac{1}{5}$ of his monthly allowance. Tom ate $\frac{2}{5}$ of the cake and Sue ate another $\frac{2}{5}$ of the cake. How much of the cake did Tom and Sue eat?		
3	Johnny had 'a' notebooks. Mary has 2 more notebooks than Johnny does. How many notebooks does Mary have?		

1 = Not At All A Good Problem 2 = Somewhat A Good Problem 3 = Undecided 4 = A Good Problem 5 = A Very Good Problem

#	Problem & Your Solution	Rating (1-5)	Explain Your Rating
4	There are 8 pitchers for sale at the market. Mrs. Brown buys 2 pitchers. How many pitchers left?		
5	Which of the following numbers does not belong with the others? Explain. 4, 36, 25, 11		
6	For a salad, Mary used $3\frac{1}{2}$ pounds of apples, $\frac{1}{3}$ pounds of nuts, and $\frac{3}{4}$ pounds of raisins. How many pounds of the salad did Mary make in all?		

1 = Not At All A Good Problem 2 = Somewhat A Good Problem 3 = Undecided 4 = A Good Problem 5 = A Very Good Problem

#	Problem & Your Solution	Rating (1-5)	Explain Your Rating
7	Find two fractions that are between $\frac{1}{4}$ and $\frac{1}{2}$.		
8	You are about to ask your friend to guess the secret number you wrote in the paper, which is 25. One clue is given for your friend here. Make up two more clues: "The number is a less than 30."		
9	Fill the blank: 30 is ____ percent of 120.		

1 = Not At All A Good Problem 2 = Somewhat A Good Problem 3 = Undecided 4 = A Good Problem 5 = A Very Good Problem

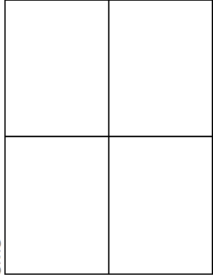
#	Problem & Your Solution	Rating (1-5)	Explain Your Rating
10	Make up a problem about students in the classroom using the following formula: $30 - x = 28$		
11	Sandy earned \$350 and spent $\frac{3}{5}$ of it. How much money did she have left?		
12	A man can build a garage in 12 days. if 12 people who have the equal ability as the man work together, how long will it take to build the garage? if 288 people work together how long will it take to build the garage?		

1 = Not At All A Good Problem 2 = Somewhat A Good Problem 3 = Undecided 4 = A Good Problem 5 = A Very Good Problem


#	Problem & Your Solution	Rating (1-5)	Explain Your Rating
13	Calculate: $\frac{3}{5} + \frac{2}{5} + \frac{1}{5}$		
14	Decode the following message: "NZGS RH UFM!"		
15	Which unit would you use to find the length of a pencil? (a) cups (b) inches (c) pounds (d) yards		

1 = Not At All A Good Problem 2 = Somewhat A Good Problem 3 = Undecided 4 = A Good Problem 5 = A Very Good Problem

#	Problem & Your Solution	Rating (1-5)	Explain Your Rating
16	There were 8 flower pots in the garden. Limmy put more flower pots in the garden and now there are 5 flower pots in the garden. How many flower pots did Limmy put in the garden?		
17	You are about to ask your friends to think of a number between 2 and 10. You want to ask them to conduct the following operations: "Multiply the number by 9. Add the digits in the product. Then, take away 5 from the sum. What is your answer?" How many different answers do you expect? Explain.		
1 = Not At All A Good Problem 2 = Somewhat A Good Problem 3 = Undecided 4 = A Good Problem 5 = A Very Good Problem			

#	Problem & Your Solution	Rating (1-5)	Explain Your Rating
18	<p>The following map shows all the roads from my home to school. How many different paths can you find without backtracking?</p> 		
19	I bought five T-shirts for \$10 for each. How much money did I spend?		

1 = Not At All A Good Problem 2 = Somewhat A Good Problem 3 = Undecided 4 = A Good Problem 5 = A Very Good Problem

#	Problem & Your Solution	Rating (1-5)	Explain Your Rating
20	How much did your household pay for the electricity last year? What is the monthly average cost?		
21	Think about the number 6 broke into two different amounts. Draw a picture to show a way that six things can be broken into two parts. Think up a story to go with your problem		
22	Place an X on the number line about where $\frac{11}{8}$ would be. Explain why you put your X where you did. Perhaps you will want to draw and label other points on the line to help explain your answer. 		

1 = Not At All A Good Problem 2 = Somewhat A Good Problem 3 = Undecided 4 = A Good Problem 5 = A Very Good Problem

#	Problem & Your Solution	Rating (1-5)	Explain Your Rating
23	Jack and Jill were at the bottom of a hill, hoping to fetch a pail of water. Jack walks uphill at 5 steps every 25 seconds, while Jill walks up at 3 steps every 10 seconds. Assuming a constant walking rate, who will get to the pail of water first?		
24	Clara has 2 whole pizzas and $\frac{1}{3}$ of another. All the pizzas are the same size. If each of her friends will want to eat $\frac{1}{4}$ of a pizza, how many friends will she be able to feed with the $2\frac{1}{3}$ pizzas?		
25	Calculate $32 \div 47$. Can you show more than one way?		

Questions 1-24 taken from:
 Lee, E. J., & Kim, K. T. (2005). Elementary school teacher candidates' perceptions of good problems. Issues in the Undergraduate Mathematics Preparation of School Teachers, 1, 1-13.
 Van de Walle, J. A., Karp, K. S., & Bay-Williams, J. M. (2010). Elementary and Middle School Mathematics: Teaching Developmentally Instructor's Copy (7th ed.). Boston: Allyn & Bacon.

1 = Not At All A Good Problem 2 = Somewhat A Good Problem 3 = Undecided 4 = A Good Problem 5 = A Very Good Problem

Appendix E: Lion Cub Problem

The Lion Cub Problem

Lion cubs were born at the local zoo last week. The zookeeper weighed them two at a time, and got weights of 13, 14, and 15 pounds. How many lion cubs were there and what was the weight of each lion cub to the nearest pound?

Problem taken from:

Krulik, S. & Rudnick, J. A. (1998). *Assessing reasoning and problem solving: A sourcebook for elementary school teachers*. Boston: Allyn & Bacon.

Appendix F: Rabbit Problem

The Rabbit Problem

A rabbit is going to hop up a flight of 10 steps. He can only hop up 1 or 2 steps at a time. He never hops down, only up. How many different ways can the rabbit hop up the flight of 10 steps?

Appendix G: Beliefs Survey

Using the scale below, indicate your level of agreement with each of the following (circle one).

1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree

1. Children learn mathematics best when they are actively involved. 1 2 3 4 5
2. Children need opportunities to construct their own understanding
in mathematics. 1 2 3 4 5
3. It is more important for children to know their basic facts and be
able to compute quickly than to solve word problems. 1 2 3 4 5
4. The way I teach mathematics is influenced by the textbook I use. 1 2 3 4 5
5. The problem-solving activities I use come mainly from my textbook. 1 2 3 4 5
6. Doing mathematics consists mainly of using rules. 1 2 3 4 5
7. Students need to know the “key word” approach to problem solving. 1 2 3 4 5
8. I create the majority of the problem-solving activities I use. 1 2 3 4 5
9. Getting the one, correct answer is the most important part of
elementary mathematics. 1 2 3 4 5
10. It is better to tell students how to solve problems than to let them
discover how on their own. 1 2 3 4 5

11. I usually try to understand the reasoning behind all of the rules I use
in math. 1 2 3 4 5
12. Being able to successfully use a rule or a formula in mathematics
is more important to me than understanding why and how
it works. 1 2 3 4 5
13. It is difficult to talk about mathematical ideas because all you can
really do is explain why and how it works. 1 2 3 4 5
14. Solving mathematics problems frequently involves exploration. 1 2 3 4 5
15. Most mathematics problems are best solved by deciding on the
type of problem and then using a previously learned solution
method for that type. 1 2 3 4 5
16. It is difficult to be creative when teaching mathematics. 1 2 3 4 5
17. In mathematics, there is always a rule to follow. 1 2 3 4 5
18. It is important for students to create and solve their own problems. 1 2 3 4 5
19. Calculators are useful in solving word problems. 1 2 3 4 5
20. Children can develop their problem-solving skills by working
together in small groups. 1 2 3 4 5
21. Teachers should tell students the best way to solve each type
of problem. 1 2 3 4 5
22. Students need to be given the right answer to all of the problems
they work. 1 2 3 4 5
23. Hearing different ways to solve the problem confuses children. 1 2 3 4 5

24. Learning mathematics mainly involves memorizing procedures

and formulas.

1 2 3 4 5


Survey taken from: Barlow, A. T., & Cates, J. M. (2006). The impact of problem posing on elementary teacher's beliefs about mathematics and mathematics teaching. *School Science and Mathematics, 106*(2), 64-73.

Appendix H: Human Studies Review Board Approval



Office of Research Integrity and Assurance
Research Hall
4400 University Drive, MS 6D5, Fairfax, Virginia 22030
Phone: 703-993-4121; Fax: 703-993-9590

TO: Margret Hjalmarson, College of Education and Human Development

FROM: Aurali Dade
Assistant Vice President, Research Compliance 

PROTOCOL NO.: 8540

PROPOSAL NO: N/A

TITLE: A Case Study of Novice Teachers' Problem Solving Beliefs and Perspectives

DATE: February 20, 2013

Cc: Courtney Baker

Under George Mason University (GMU) procedures, this project was determined to be exempt by the Office of Research Integrity & Assurance (ORIA) since it falls under DHHS Exempt Category 2, research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior.

A copy of both approved consent documents is attached. Please use the stamped documents for your research.

You may proceed with data collection. **Please note that all modifications in your protocol must be submitted to the Office of Research Subject Protections for review and approval prior to implementation.** Any unanticipated problems involving risks to participants or others, including problems regarding data confidentiality must be reported to the GMU Office of Research Subject Protections.

GMU is bound by the ethical principles and guidelines for the protection of human subjects in research contained in The Belmont Report. Even though your data collection procedures are exempt from review by the GMU HSRB, GMU expects you to conduct your research according to the professional standards in your discipline and the ethical guidelines mandated by federal regulations.

Thank you for cooperating with the University by submitting this protocol for review. Please call me at 703-993-5381 if you have any questions.

Appendix I: Instructor Protocol

1. How do you feel about learning mathematics? How do you feel about teaching mathematics?
2. Describe your mathematics methods classes.
 - a. Prompts: What are the students doing? What is the teacher doing? What type of work is being done? What is your population like?
3. How do you plan for incorporating problem solving?
 - a. Prompts: Does anyone help you? What materials do you use? Do you plan at home or at school? Do you enjoy teaching math? Do you enjoy planning math? How much time do you spend preparing for math? Are you comfortable teaching math?
4. What role does problem solving play in the mathematics methods course?
 - a. Prompts: Where do you get your problem solving activities from? Do you make them yourself? Look on-line? Use the textbook?
5. How do you expose pre-service teachers to problem solving?
 - a. Prompts: Is problem solving a unit? Is problem solving embedded within your teaching? Are there specific strategies that you teach? What are they? Key word, etc. With what frequency do you incorporate problem solving? How is problem solving incorporated into the coursework? The assignments?
6. What is your reaction to the following statement? The most important part of elementary mathematics is getting the one correct answer.
 - a. Prompts: Is it possible for a problem to have multiple solutions? Why or why not? How is this presented to pre-service teachers?
7. How do children learn problem solving best?
 - a. Prompts: actively involved, textbook, hands-on, formulas, calculators
8. How do pre-service teachers learn problem solving best?
 - a. Prompts: actively involved, textbook, hands-on, formulas, calculators
9. What is challenging about teaching problem solving?

- a. Prompts: Finding resources, being creative, etc.
 - b. What is challenging about teaching mathematics to pre-service teachers?
- 10. Describe an individual, a pre-service teacher, who has a good understanding of problem solving.
 - a. Prompts: What do they know? What do they do? How do they plan? What does a typical math lesson look like?
- 11. How does your methods course compare to the university's other math methods course?
 - a. Prompts: What is the same? What is different?
 - b. Prompts: assignments, rubrics, discussion, coursework, etc.
- 12. Let's take a look at the following problem: Lion cubs were born at the local zoo last week. The zookeeper weighed them two at a time, and got weights of 13, 14, and 15 pounds. How many lion cubs were there and what was the weight of each lion cub to the nearest pound?
 - a. What is your first reaction to the problem?
 - b. What is the problem asking you to find?
 - c. Describe the possible strategies you would use to solve the problem?
 - d. What strategies would you expect pre-service teachers to come up with?
 - e. Describe the process and mathematics used to solve the problem.
 - f. Could you have used another strategy? Was your strategy the most efficient? Does your solution make sense? Why or why not? Are you confident about your solution?
 - g. Could you use this problem in your teaching? Describe how.
 - h. Was this problem a good problem? Why or why not? What would make this problem a good problem?
- 13. Let's take a look at the following problem: A rabbit is going to hop up a flight of 10 steps. He can only hop up 1 or 2 steps at a time. He never hops down, only up. How many different ways can the rabbit hop up the flight of 10 steps?
 - a. What is your first reaction to the problem?
 - b. What is the problem asking you to find?
 - c. Describe the possible strategies you would use to solve the problem?
 - d. What strategies would you expect pre-service teachers to come up with?
 - e. Describe the process and mathematics used to solve the problem.
 - f. Could you have used another strategy? Was your strategy the most efficient? Does your solution make sense? Why or why not? Are you confident about your solution?
 - g. Could you use this problem in your teaching? Describe how.
 - h. Was this problem a good problem? Why or why not? What would make this problem a good problem?

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Biography

Courtney K. Baker graduated from James Madison High School, Vienna, Virginia, in 1997 and received her Bachelor of Science in Animal Science from Virginia Polytechnic Institute and State University in 2002. She was employed as a teacher in Fairfax County for five years prior to becoming an Elementary Mathematics Resource Teacher in 2011. She received her Master of Education in Mathematics Education Leadership from George Mason University in 2008.