PRE-SERVICE TEACHERS' PERCEPTIONS OF THEIR K-12 MATHEMATICS EDUCATION EXPERIENCES AND THEIR FUTURE MATHEMATICS TEACHING PRACTICES

by

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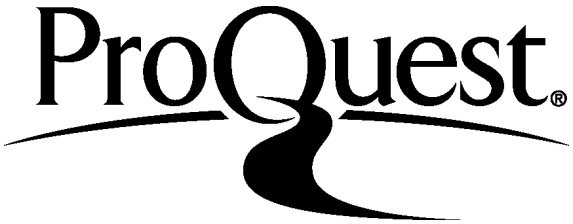

THESIS APPROVAL

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So many students enter college without the conceptual knowledge of mathematical principles needed in order to succeed in higher education. Pre-service teachers entering teacher education programs are not exempt from this dilemma. While training to be educators, many pre-service teachers struggle to understand the concepts behind elementary level mathematics. These pre-service teachers will then continue in the education field and teach mathematics to the future generation. Will they teach their students the way they were taught?

The purpose of this study is to investigate how pre-service teachers view their past experiences with math during their K-12 education and to compare those views with their perceptions of how they will teach math in the future. Using both quantitative and qualitative methods through surveys, short answer responses, and interviews, this study examines 38 pre-service teachers currently taking math methods courses at Southern Illinois University Carbondale in order to find out (1) how pre-service teachers view their past experiences with mathematics during their K-12 education, (2) what pre-service teachers' visions of how they will teach mathematics to their students in the future are, (3) which appears to have more influence on pre-service teachers' perceptions of their own future math teaching practices: their past learning experiences

or their current teacher preparation program, and (4) what pre-service teachers perceive as effective ways of mathematics teaching and learning.

Findings revealed that pre-service teachers tend to view their past K-12 math education experiences as mostly consisting of steps and procedures they were taught to memorize, but they have strong feelings about teaching mathematics for conceptual understanding instead of focusing on memorization like they were taught during their math classes in K-12 education. The results from this study also revealed that pre-service teachers feel it will be difficult not to fall back on the way they were taught mathematics when encountering unfamiliar concepts they have to teach. The need for more field experiences and learning how to incorporate project-based learning and presenting diverse ways of problem solving also came out as ways to improve teacher education programs.

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CHAPTER 1

INTRODUCTION AND BACKGROUND

"All I know are formulas. I do not know why most problems are solved the way they are" (Survey Response, December 10, 2015), responds one pre-service teacher when asked why she would not teach mathematics the way she was taught during her own K-12 education. Could this response be revealing a possible reason why students, even college students, try to apply mathematical formulas to the wrong problems? If all they know are formulas and they do not understand why they are using the formulas, they are more likely to misapply those formulas they think they know. As I have personally witnessed as an educator, many times the formulas students try to use do not even make sense with the problems they are given. How does this happen? A big factor that contributes to these symptoms is the direct-teach approach by many K-12 math educators (Fuentes, Bloom, & Peace, 2014; Ball, 1988).

When math problems are not broken down so that students can understand the underlying concepts of the problems, the result is usually memorization and not true understanding. As the pre-service teacher stated so clearly above, she does not know why the problems are solved in certain ways. In other words, she does not understand the concept behind the formula or why that specific formula is used in the type of problem she is given. The "why" behind mathematical principles is extremely important. When students do not understand the mathematical concepts, they begin to get frustrated and develop negative attitudes toward mathematics.

This dilemma also extends to pre-service teachers. It appears that many of the students entering teacher education programs do not have a solid foundation of

understanding the concepts that underlie basic mathematical principles. The majority of a group of pre-service teachers who completed the 8th grade level Ohio Achievement Math Practice Test only answered correctly 50% or less of the math questions given (Rosas & Campbell, 2010). These pre-service teachers were prospective educators who would be teaching math to students in the future, but they did not understand 8th grade level mathematics.

Does the lack of conceptual knowledge impact how well pre-service teachers will teach mathematics to their students? Not only have studies shown a negative impact on the opportunities provided to students when teachers have a lack of mathematical understanding (Darling-Hammond, 2000), but this lack of understanding in turn diminishes pre-service teachers' confidence levels in teaching mathematics (Brady & Bowd, 2005; Fuentes et al., 2014). Even with this background, there are still pre-service teachers who have perceptions that math is primarily about using procedures to get answers, regardless of whether or not the concepts behind the procedures are understood (Fuentes et al., 2014).

How does this problem of students entering college without a basic understanding of mathematical principles get fixed? It is crucial to catch the deficiency early in the area of equipping pre-service teachers for educating future math students, so that the current problem is not perpetuated. When children enter school at the preschool level, they have not yet had negative encounters with math, do not feel their ability levels are being compared with other children, and do not have the pressure of making a specific grade (Fisher, Dobbs-Oates, Doctoroff, & Arnold, 2012). They just enjoy learning and doing math! But at some point later in these preschoolers'

mathematics education experiences, negative attitudes toward mathematics begin to develop. If elementary teachers foster the development of and set examples for positive attitudes and conceptual understanding in mathematics and also support students throughout their mathematics educational experience, students entering high school and college would more than likely have a much more productive perspective of math than most students do now.

Are pre-service teachers being prepared well enough in teacher education programs in order for them to teach mathematics in a way that will positively impact student learning? Clarissa Rosas and Mary West (2011) found that the pre-service teachers in their study only felt adequately prepared to teach mathematics, and this was during the pre-service teachers' last semester of coursework. A teacher education program may not be able to teach all of the mathematical concepts that are lacking in pre-service teachers' prior knowledge, but can the programs be designed or enriched to help pre-service teachers meet the desperate need for mathematical conceptual understanding and cultivate a desire to explore those concepts on their own before teaching them?

Purpose and Design of the Study

There is a need to initiate a positive change in mathematics education, and this begins with the pre-service teachers before they enter the field of education. The purpose of this study is to investigate pre-service teachers' perceptions of their past experiences with learning math during their K-12 education and to compare those perceptions with their perceptions of how they will teach math in the future. The overall design of this study's research is rooted in action research, which is an inquiry process

where current practices are investigated, questions are formed, data are collected, and reflections are made for sustainable educational improvement. The research findings from the study are then used to inform the current practices and provide an avenue of change for the future (Ferrance, 2000).

This study seeks to investigate the current practices of preparing pre-service teachers in the area of teaching mathematics. Many pre-service teachers enter the teacher education program with a lack of mathematical conceptual understanding. From where did this lack of foundation come? What type of mathematical experiences have pre-service teachers encountered throughout their K-12 education? How can we prevent this lack of mathematical foundation from recurring with future students? We need to make a positive impact on the education system, especially in the area of mathematics teaching and learning. This begins with our preparation of pre-service teachers among a variety of other factors.

Research Questions

The primary purpose of this study is to look at the perceptions that pre-service teachers currently taking math methods courses have about their own K-12 mathematics education experiences and the perceptions they hold about their future teaching practices in order to discover the influences that past learning experiences with mathematics and current experiences in the teacher education program have on pre-service teachers. Do they see themselves teaching mathematics the way they were taught? Why or why not? In the process of investigating this goal, the following research questions will be addressed:

(1) How do pre-service teachers view their past experiences with mathematics during their K-12 education?

(2) What are pre-service teachers' visions of how they will teach mathematics to their students in the future?

(3) Which appears to have more influence on pre-service teachers' perceptions of their own future math teaching practices: their past learning experiences or their current teacher preparation program?

(4) What do pre-service teachers perceive as effective ways of mathematics teaching and learning?

Significance of the Study

Most of the pre-service teachers who are currently in the teacher education program have not been taught under the ongoing Common Core Reform. Even though they did not experience their K-12 education under these standards, they will be required to teach according to them. One of the primary focuses of the Common Core Reform in the area of mathematics is to develop conceptual understanding in students, so that they see mathematical principles as more than just a set of procedures or mnemonics (Common Core State Standards Initiative [CCSSI], 2015). Conceptual understanding of mathematical principles is a key component of the education reform, which greatly impacts pre-service teachers who did not have the Core-style math experience.

There has been much debate over the implementation of the Common Core State Standards, but it is important to remember what educational standards are. They are simply a set of statements that reflect our society's current values, priorities and

goals (Hiebert, 1999). The Common Core Standards do not dictate to a teacher how to teach, but instead they reflect what we as a society value about our students' education and what we expect as the outcome of knowledge and ability levels upon graduation from each grade level. Over time, our society has changed and with that the values and expectations have changed. What was once considered the desired outcome (memorization, knowledge of facts, and basic computation) is no longer the expectation of our society. We desire that our students not only understand the concepts beyond the surface, but that they understand them well enough to apply those concepts outside the classroom walls also (CCSSI, 2015).

Why might our societal values (standards) in mathematics education have changed? Is it possible that new technologies, such as PhotoMath, which solves problems for students with the simple click of their camera button (Owano, 2014), have brought to light the need for more than just basic memorization? A 21st-century tool needs a 21st-century response. In light of new technologies and societal value changes, we cannot continue educating as we always have in the past. The shift in technology and societal values reveals that we value not just memorization, but conceptual understanding and application to real life. "It is not enough to just memorize multiplication tables. Students now need to understand what multiplication is and how it works so that they can use the principles of multiplication in situations outside of simple multiplication or fact practice" (Godbold, 2013, para. 12). If students understand how the mathematical principles work, they are more likely to be able to apply them to other real-world problems. "In a sense we are coming back to teaching children for life not covering material for the sake of checking off the list" (Godbold, 2013, para. 14).

Society values life application and the use of mathematical principles more than mere recitation of math facts, which is reflected in the new educational reform and current standards.

How does this affect teachers? They will be required to have deeper mathematical content knowledge than they have ever been asked to have before now (Godbold, 2013). This also impacts pre-service teachers. As they are entering the field of education, they will also need this deep understanding of mathematical principles. Pre-service teachers must complete the requirements of edTPA (Teacher Performance Assessment), which uses a similar process to that which is used for National Board Certification (American Association of Colleges for Teacher Education, 2015; Stanford Center for Assessment, Learning, & Equity, 2015). It attempts to raise the standards of the licensure process for pre-service teachers, but it has become a high stakes assessment procedure. National Board Certification is a difficult process for experienced teachers, let alone pre-service teachers of whom many do not have the foundations of conceptual understanding in mathematics.

The raising of the standards in EdTPA reflects the change in values of what we as a society expect of our pre-service teachers and what they will be able to teach to their students. Some of those expectations in the capstone assessment include: (a) providing explanations for mathematical information and making appropriate inferences from those explanations, (b) deepening understanding by converting important information into meaningful mathematics representations, (c) drawing insightful conclusions and making deep judgments based on quantitative data analysis, and (d) describing assumptions and providing compelling rationales for why those assumptions

make sense (Association of American Colleges and Universities, 2014). These mathematical expectations are under the quantitative literacy component.

What is quantitative literacy? It is not just computing information. It is much deeper than that. It involves a level of comfort and competency when dealing with numerical data and the ability to analyze that data in order to make connections and draw appropriate conclusions (Association of American Colleges and Universities, 2014; Matheny, 2009, De Lange, 2003). It entails "the ability to reason and solve quantitative problems from a wide array of authentic contexts and everyday life situations" (Association of American Colleges and Universities, 2014, para. 2). Those who possess quantitative literacy are able to provide evidence for why a mathematical statement is accurate. In order to do this, it is imperative to have deep conceptual understanding of mathematical principles and not just surface level memorization of procedures and formulas. Just because students can solve a problem, it does not mean they understand the meaning of their work. To teach quantitative literacy, educators must create assignments that go beyond computation. It is important to deal with authentic, data-based problems where connections can be made and critical thinking can take place (Association of American Colleges and Universities, 2014; Matheny, 2009).

It is obvious from these expectations of mathematical or quantitative literacy that our education system requires more than rote memorization and following mathematical procedures. How can our Teacher Education Program (TEP) help support these pre-service teachers, and how can we instructionally design our program so that it considers and takes advantage of the pre-service teachers' prior experiences with

mathematics, whether those experiences are positive or negative? There seems to be a gap in literature when it comes to exploring pre-service teachers' K-12 mathematics experiences and further using them to support the implementation of the Common Core Standards for Mathematics and other related assessment initiatives. This study is an effort to obtain a deeper understanding of pre-service teachers, document their mathematics backgrounds, and hear their voices in order to better design instruction and intervention to support them in TEP and their future careers.

This study uses a targeted sample consisting of 38 undergraduate students enrolled in a math methods course in the Curriculum and Instruction department at Southern Illinois University Carbondale during the Fall 2015 semester. Both quantitative and qualitative data are collected using surveys and interviews. Existing data from pre-tests are also used in order to show the course entrance level of mathematical conceptual knowledge held by the pre-service teachers. Data collected during this study is analyzed according to the research questions previously stated in order to discover the pre-service teachers' perceptions of their past experiences in mathematics education, their future expectations about teaching mathematics, their beliefs on the best methods for helping students learn math, and the impact of their teacher education program.

To sum up, the mathematics education that students receive during their K-12 years of schooling is extremely important. Just as in building a house you must first lay a foundation, a proper mathematics foundation must be laid where conceptual knowledge and mathematical literacy are components of the foundation upon which future mathematical concepts can be built. If a proper foundation is not laid in all

academic subject areas, the students may have difficulty when they enter college. "Recent federal data indicated that 68 percent of all community college students and 40 percent of students at public, four-year colleges take at least one remedial course" (American Association of Community Colleges, 2014).

Where does the proper foundation laying begin? It begins with pre-service teachers. Whether or not pre-service teachers have received a K-12 mathematical education that involved conceptual understanding and quantitative literacy, there must be a change in how they will instruct their students in the future so that one does not see such a high number of college students needing a remedial or developmental mathematics course before taking college-level mathematics classes. It is important that pre-service teachers do not perpetuate the fear of math and lack of conceptual understanding to their students. A change in mathematics education is needed, and it begins with the students who are studying to be teachers.

CHAPTER 2

LITERATURE REVIEW

"Many teachers only taught the formulas. If I forgot the formula, I would be completely lost" (Survey Response, December 10, 2015). This is the response of one pre-service teacher when asked why she oftentimes felt lost in her previous K-12 math classes. Unfortunately, many students feel lost in mathematics courses even if they remember the formulas. Why? The response from another pre-service teacher sheds light on this question: "Math was often meaningless formulas in my experiences." This may be due to students seeing and being taught formulas as plug-and-play games and not as concepts that have meanings.

Formulas are not created out of thin air. There are meanings behind all formulas. Unfortunately, many students are not taught what those meanings are or why they are important. They are simply taught to memorize the formulas. One pre-service teacher reflects back on her experience in K-12 math classes and states, "I was not capable of memorizing copious amounts of formulas in one sitting like most of my peers. The teacher would move on before I could understand the concept, and I wasn't able to do my homework" (Survey Response, December 10, 2015). This is a sad commentary on mathematics education. "Eventually students get the point that what 'learning' means is that they are supposed to memorize the words contained in the lesson and repeat them for the teacher" (Sergiovanni, Starratt, & Cho, 2014, p. 83). This is not what mathematics education should look like, and it is not the message that should be sent to students.

Imagine the following problem: "Three people walk into a classroom. One person's height is 3 ft, another person's height is 4 ft, and the third person's height is 8 ft. If they each lie down head to toe with each other, could they form a triangle?" When solving this problem, what concepts do the students need to know? Is the Pythagorean Theorem necessary for solving this type of problem? When a similar problem was given to the pre-service teachers in a math methods course during this study, the majority of the students used the Pythagorean Theorem in order to support their answers that the three lengths they were given would not be able to form a triangle. Is this theorem needed to support the statement that it is impossible for the three lengths to form a triangle?

No where in the problem is it stated that a right triangle is to be formed with these lengths. Since the Pythagorean Theorem is to be applied with right triangles, what does this reveal about the thinking behind the responses of these pre-service teachers? It appears that the students saw the word "triangle" and thought they needed to use the Pythagorean Theorem. Why? Do these students truly understand what the Pythagorean Theorem is, when it is used, and why it is used? Is the conceptual understanding about how a triangle (no matter what type) is formed evident in these pre-service teachers' responses? Most of these pre-service teachers have memorized formulas, but do not truly have a grasp on the conceptual understanding behind the mathematical formulas they have memorized. We will explore more on that later.

One may ask why it is important to discover what pre-service teachers believe. Are perceptions really important in the arena of mathematics education? Stipek,

Givvin, Salmon, and MacGyvers (2001) found that there is a reliable association between what teachers believe and what they choose to do in the classroom. If this is the case, then in turn, can we improve what happens in the classroom by looking at and influencing teachers' and pre-service teachers' beliefs and perceptions? "The goal is to better understand the nature of teachers' beliefs about mathematics teaching and learning and the links between their beliefs and practices" (Stipek et al., 2001, p. 213). If we can influence how teachers' view mathematics teaching and learning, their attitudes and perspectives may change, which then could greatly impact how they teach in the future (Stipek et al., 2001; van der Sandt, 2007).

Unfortunately, mathematics is often taught as a set of procedures and step-by-step instructions about how to solve problems in order to obtain a correct answer instead of using inquiry and laying a foundation of conceptual understanding regarding mathematical principles (Stipek et al., 2001; Fuentes, Bloom, & Peace, 2014; Ball, 1988). Making sense of problems and connecting them to real life is vital in all areas of learning, including mathematics. About fraction division, for example, Sergiovanni and colleagues (2014) wrote in their reflection:

> Learning about the division of a fraction by another fraction requires that students be presented with concrete instances from their real world and asked to describe what they see, using words from their own storehouse of words, and to explore how they might divide something into smaller, but equal parts from something already divided. In the actual doing of it, they come to see what the activity involves and how to begin to create equal measures of something...in all its various forms learning can be said to involve sense-making, an ongoing

inquiry into how things work and how we go about finding out how things work, how one thing is related to another. (Sergiovanni et al., 2014, pp. 84-85)

When sense-making and conceptual understanding is absent in mathematics education, the students are set up for failure because they do not truly understand the concepts behind mathematical principles and how these principles relate to real-world experiences. When those students continue on to be mathematics educators themselves, if they have not truly learned the mathematical concepts which underlie those principles, they perpetuate the lack of mathematical understanding and negatively impact their students, depriving them of the opportunities to learn meaningful mathematics (Davis, 2011; Stipek et al., 2001; Ernest, 1989; Ball, 1988). We especially see this in the elementary grades. It appears to be a domino effect that is perpetuated over time. If mathematics educators do not have a proper grasp of the conceptual understanding behind mathematical principles, they become less confident in their abilities to teach those concepts to students (Brady & Bowd, 2005; Fuentes et al., 2014). The lack of the teachers' mathematical abilities along with their lack of confidence in teaching the concepts negatively impacts the confidence level and learning opportunities of their students (Darling-Hammond, 2000; Stipek et al., 2001; Fuentes et al., 2014). We must stop this cycle in mathematics education.

Since the teachers' self-confidence level for teaching mathematics will fluctuate based on their mathematical ability levels, this will also affect whether or not teachers decide to engage their students in inquiry-based mathematics learning (Stipek et al, 2001). To facilitate this type of learning, the teacher must feel sufficiently comfortable and knowledgeable of the mathematical concepts in order teach those concepts (Ball,

1988) and scaffold the activity appropriately for his or her students. Stipek et al. (2001) states this clearly when describing the results from their study on 21 fourth- through sixth-grade elementary teachers in Los Angeles County of California:

> As predicted, teachers who embraced more traditional beliefs about mathematics and learning had lower self-confidence and enjoyed mathematics less than teachers who held more inquiry-oriented views. We suspect that less confident teachers are drawn to a set of beliefs and practices that require relatively less teacher judgment and decision-making. Teachers who focus on procedures and correct answers can teach in a very prescribed way, following the procedures described in the textbook and even using the answer sheets in the teacher's manual to correct student work. Teachers who focus on students' own or socially constructed understanding of mathematics need to analyze the meaning of students' errors and strategies and to provide instructional input that is directly linked to those analyses. If our speculation is valid, building teachers' self-confidence in math, which requires building their mathematical understanding, could be an important, if not necessary, ingredient in moving them toward more inquiry-oriented beliefs and practices. (Stipek et al., 2001, p. 223)

Is it not the responsibility of teachers to be able to diagnose not only where a student goes wrong on a math problem, but also the possible reasons why the student may have gone that wrong direction? In order to do this, the teachers must have a true conceptual understanding of the mathematical principles themselves and also a knowledge of how students learn (van der Sandt, 2007; Skemp, 2006; National

Research Council, 2005; Ball, Hill, & Bass, 2005; National Council of Teachers of Mathematics, 2000; Ball, 1993) in order to diagnose and assess mathematical misconceptions in their students (Ball, 1988). Teachers need to be able to approach a problem from various angles, understand several ways to solve the same problem, and be able to implement various methods in communicating the mathematical concept (Ball, 1988). If they are not able to see or understand various problem-solving strategies, their students "may miss opportunities to develop robust and flexible understandings" (Davis, 2011).

Fuentes, Bloom, and Peace (2014) point out that in order for teachers to be effective in teaching mathematics to students, they must possess three areas of math content knowledge: (a) common content knowledge, which is the basic information for solving problems; (b) specialized content knowledge, which is not only knowing how to solve problems, but also understanding the underlying concepts of those problems; and (c) horizontal content knowledge, which is the ability to connect mathematical topics across the curriculum. One may think that this is what all teachers would believe they should be able to do, but unfortunately, this is not the case. Since most elementary teachers are not masters of subject areas, but are masters of teaching children, they may not feel comfortable in delving deep into the concepts behind math and science, especially if they were not meaningfully taught those concepts while they were in elementary school.

The study by Fuentes et al. (2014) investigates what pre-service teachers think they need to know in order to teach math and science to kindergarten through sixth grade students. PETSMA, pre-service elementary teachers science and mathematics

activity, was given to 50 pre-service teachers at the beginning of their teacher education program while they were enrolled in science and mathematics methods courses in order to discover their perspectives on teaching. This activity contains several pairs of questions about K-6 grade level math and science topics. Each pair of questions consists of a factual/procedural question and a conceptual question related to the factual/procedural question. Both the factual/procedural and the conceptual questions are then followed with Likert-style questions intended to measure the pre-service teachers' confidence level in his or her ability to answer the questions and teach the content. Based on the responses, the study reveals the individuals' beliefs about the content knowledge needed for teaching elementary math and science.

With regard to teaching mathematics, the results from the study by Fuentes et al. (2014) show that the pre-service teachers' perceptions of math primarily consist of using procedures, formulas or steps to get answers to problems, even if the concepts behind the procedures are not understood. Most comments by the pre-service teachers reveal that their perceptions seem to come from their own past learning experiences while in school. Overall, these pre-service teachers feel more confident in answering mathematics questions than in teaching the content related to those questions. This shows they are inclined to place an emphasis on the necessity of knowing or being able to explain the mathematical concepts. They feel that they simply need to be able to carry out the mathematical procedures in order to teach elementary level mathematics.

Based on the comments provided from the study conducted by Fuentes and colleagues, it is not surprising that the pre-service teachers mostly knew math based on

factual and procedural knowledge. One comment given by a pre-service teacher stated, "I feel like in math, every time you get the answer it's because you had a formula or a step-by-step process" (as cited in Fuentes et al., 2014, p. 33). This is very possibly because it was how they were primarily taught at the elementary school level. This is revealed by another pre-service teachers' comment:

> In math, it was just - we're not going to explain it to you because this is the way you do it and that's it. There is no other way, so do it this way and follow the formula and you'll be fine. (as cited in Fuentes et al., 2014, p. 34)

This study by Fuentes et al. (2014) is insightful and enlightening for the teacher education field, especially when making decisions on how to prepare pre-service teachers for teaching the subject of mathematics. All pre-service teachers have their own experiences in mathematics education that they bring with them to the teacher education program (Ball, 1988), and we must consider this when making decisions about the structure of teacher education programs.

As mentioned previously in chapter one, pre-service teachers do not feel confident in teaching mathematics when they do not truly understand the underlying concepts (Brady & Bowd, 2005; Fuentes et al., 2014). Rosas & Campbell (2010) found that in one group of pre-service teachers, the majority of them could only answer correctly 50% or less of the 8th grade level math questions on an Ohio Achievement Math Practice Test. Unfortunately, there are pre-service teachers who do not realize how much they are lacking in mathematical understanding. Fuchang Liu (2011) reveals this through very candid responses by pre-service teachers during his qualitative case study conducted at a university in the U.S. Midwest metropolitan area. In Liu's study,

data were collected over a span of two consecutive semesters with a total of 62 pre-service teacher participants who were taking math methods courses directly prior to student teaching. Online discussions were used to elicit participants' thoughts about departmentalizing elementary schools, especially in the area of mathematics. Each pre-service teacher was to post at least twice a week to the online discussion board. The posts were then analyzed based on themes that emerged from the pre-service teachers' responses.

Various themes emerged from the pre-service teachers responses in Liu's study (2011). One of those themes was that not all pre-service teachers realized how much they did not know about mathematical concepts. This is displayed in one pre-service teachers' response, "...it's not like the subjects are all that difficult. We all passed 5th grade so it is not like we don't know the information" (as cited in Liu, 2011, pp. 50-51). Another pre-service teacher states, "Even though it is true that we all have our strengths and weaknesses in subject areas, elementary knowledge of these subjects is basic enough that we should all be able to be experts at teaching all subjects" (as cited in Liu, 2011, p. 51). But do pre-service teachers have even that basic knowledge? As the study by Rosas and West (2010) revealed, the majority of the group of pre-service teachers in their study could not answer correctly more than 50% of the elementary level math questions on a given test.

If pre-service teachers do not know the math and do not realize the importance of understanding the concepts, how can they expect to teach it to their students or prepare their students for those deeper levels of understanding? Rosas and West (2011) administered a survey developed by a team of faculty representatives from

various Ohio institutes of higher education. This survey, consisting of 167 questions or statements, was given to 5,306 pre-service teachers at public and private colleges and universities in Ohio during their last semester of coursework. The survey results revealed that on a scale from 1 to 5, with 1 representing "not at all" and 5 representing "very well," pre-service teachers from both public and private institutions of higher education felt that their teacher education programs only "adequately" (value of 3 on the scale given) prepared them to teach mathematics. When responses were analyzed, they found no significant difference between the responses from pre-service teachers at public and those from private universities.

The survey in Rosas and West's study (2011) also measured the pre-service teachers' beliefs about how to teach math. The overall conclusion from the results was that these pre-service teachers did not have strong opinions either way about how they should teach mathematics. In other words, on a scale of 1 to 5, with 1 representing "strongly disagree" and 5 representing "strongly agree," the overall rating for the statements was "neither agree or disagree" (value of 3 on the scale given). There was no significant difference found between the overall responses from pre-service teachers at public and those from private universities.

This is deeply disturbing. When pre-service teachers finish their coursework in a teacher education program, they should feel more than just adequately prepared to teach mathematics and they should have opinions on what are considered effective methods and strategies for teaching mathematics (National Council of Teachers of Mathematics, n.d.). Unfortunately, we see this revolving door and continuous cycle of pre-service teachers coming into teacher education programs having not received a K-

12 mathematics education that prepares them with the understanding of mathematical concepts, but then at the end of their time in the teacher education programs, they may not feel they are well trained for the task of teaching those mathematical concepts well when they graduate. One dilemma is that if pre-service teachers enter teacher education programs without the foundation of basic mathematical concepts, there are so many concepts that need to be taught in order for them to catch up to the level where they should be at mathematically. If we could expose pre-service teachers to the need for understanding mathematical concepts prior to teaching those concepts and also show them that it is not too late for them to learn what the underlying concepts are for the mathematical principles, then those pre-service teachers may become lifelong learners and commit themselves to investigating on their own the underlying concepts of mathematical principles before they teach them to students.

These studies reveal a deep need for change in the field of mathematics education. Teachers must not only have the mathematical conceptual understanding, but must also know how students learn and how to effectively teach mathematics using appropriate methods for each student (van der Sandt, 2007; Skemp, 2006; Ernest, 1989; Davis, 2011; National Research Council, 2005). Even if pre-service teachers have high mathematical abilities, deep conceptual understanding, and feel confident in teaching mathematics, would they be fully prepared to teach mathematics to students? All of these components are vital, but it is also important that pre-service teachers understand some of the best practices for teaching mathematics or rather develop a working knowledge of mathematics for the purpose of teaching (Ball et al., 2005). The study by Ball and colleagues (2005) explored the relationship between teachers'

knowledge of mathematics and their students' gain scores. There was a significant gain in scores for the students of those teachers who performed well on the knowledge for teaching assessment that was given. Having a working knowledge of mathematics for teaching (Ball et al., 2005) is an important element to be included as part of the foundation for pre-service teachers to be prepared to teach mathematics.

As mentioned earlier, a teacher's mathematical ability will affect his or her confidence level in performing and teaching mathematical concepts. This lack of ability and confidence is then handed down to his or her students. Stipek et al. (2001) also brought to light that there is a consistent association between teachers' beliefs and practices. Therefore, mathematical ability, confidence level, and beliefs about teaching and learning mathematics are important foundations in mathematics education and in the preparation of pre-service teachers so that the cycle is broken of teachers not having the understanding of mathematical concepts and then passing that lack of foundation on to their students when they teach.

At what point does math interest enter the equation? Is it possible that a student's interest in math could affect his or her future math skill level, and could a student's math ability affect his or her interest in math? This is the focus of a study conducted by Fisher, Dobbs-Oates, Doctoroff, and Arnold (2012). Their study examines the relationship between the interest a student displays towards math and his or her math ability level. There were two Head Start centers in New England city that participated in this study. A total of 118 preschoolers (52 boys and 66 girls from ages 3 to 5 years) from eight classrooms were selected. The preschoolers were from low-income, ethnically diverse families. Using observation and teacher reports, children

were evaluated late in the fall and also in the spring, with approximately 5 months elapsing between evaluations. The observations consisted of time playing with math activities, enjoyment level based on engagement, structure of play with math activities. Following the first evaluation, a math intervention was given to half of the classrooms.

The study by Fisher et al. (2012) revealed that there was a moderate to strong relationship between math interest and math skills in the preschoolers.

> ...children initially more interested in math later demonstrated higher math skills, through increased time spent in math activities, increased levels of arousal, greater effort, deeper cognitive processing, or other mechanisms not yet identified. Similarly, children with strong skills continued to increase engagement over time, possibly due to feeling efficacious. (Fisher et al., 2012, p. 678)

As one can see, there is a close relationship between math interest and math skill. It was also discovered that sex, ethnicity and age did not have a significant relationship between math ability and interest levels, which leads one to realize that this relationship develops later than the preschool age (Fisher et al., 2012).

So often in mathematics courses, students display a fear or anxiety toward mathematics. With this fear and anxiety, negative attitudes and frustrations typically follow. From where do these feelings come? Fisher et al. (2012) reveal that students do not come to the education system with a fear of or negative attitudes toward math. Preschoolers enjoy learning math and discovering new concepts. These negative attitudes toward mathematics do not develop until later in the children's mathematics education. This is most likely due to negative encounters with math, feeling the pressure of making good grades, and seeing their ability levels compared with other

students, all of which do not happen when students initially enter preschool. I have taught math in the middle school and college environments and there is a marked difference in attitudes toward math and ability levels. If interventions can happen as early as preschool, there is a tremendous opportunity to connect children with math and increase not only their ability levels but also their interest!

Liu's (2011) study on pre-service teachers' perceptions of departmentalizing elementary education found the prevalence of math anxiety in pre-service teachers. One pre-service teacher shares, "I have had math anxiety from a bad experience with my freshman geometry teacher. I struggled with math and it has even continued into college. Although I have had some great college math instructors, I still have anxiety!" (as cited in Liu, 2011, p. 46). Another pre-service teacher shares that having an elementary teacher who is specialized in teaching mathematics would be a good idea because, "we discussed how math anxiety is often passed down to students because their teachers have math anxiety. This would no longer be a problem because those teachers would not teach math" (as cited in Liu, 2011, p. 46). Yet another pre-service teacher connects the rippling effect that having educators who love and have a deep understanding of mathematics teach the subject at the elementary grades: "Maybe there would be less math anxiety if that love were fostered at an early age" (Liu, 2011, p. 46).

Positive attitudes toward mathematics play an important role in mathematics education. Many pre-service teachers come to the teacher education program with the "baggage" of negative experiences with mathematics and they feel unsuccessful when it comes to learning mathematics (Ball, 1988). If pre-service teachers come to math

methods courses with negative attitudes toward and experiences with mathematics, what are the chances that their future students will also have negative attitudes toward mathematics if those pre-service teachers' attitudes do not change before entering the education field? According to Gagné (as cited in van der Sandt, 2007, p. 346), attitude is learned indirectly through one's educational experience and environmental exposures (Schunk, 1996, p. 392; van der Sandt, 2007, p. 346). If teachers enter the classroom with a negative attitude toward mathematics, whether it be due to a lack of conceptual understanding or past negative experiences, those negative attitudes will impact their students' attitudes toward mathematics.

As one can see, pre-service teachers' mathematical abilities, knowledge of and confidence level in teaching mathematical concepts, beliefs on how to teach mathematics, and attitudes toward mathematics are all critical components in the theoretical framework for mathematics (teacher) education. Decades of research on mathematics teaching has mapped out a complex knowledge base that helps make sense of a teacher's instructional behaviors. This knowledge base includes teachers' knowledge (regarding subject matter, students, pedagogy, and curriculum), teachers' attitudes (toward students, the subject of mathematics, and teaching mathematics), teachers' beliefs (about the nature of mathematics, teaching mathematics, and how students learn), and various interactions among these dimensions (Ball, Lubienski, & Mewborn, 2001; Koehler & Grouws, 1992; van der Sandt, 2007; Bu, Mumba, & Wright 2012).

If at some point a person's math creativity or imagination has been squashed, can it be fixed? One cannot travel back in time in order to prevent the negative

experiences with mathematics, but Sergiovanni, Starratt, and Cho (2014) explain in the following statement that it is possible to repair those negative encounters:

> Each stage or life-challenge has a healthy or an unhealthy outcome, or, in most cases, a *relatively* satisfactory or unsatisfactory outcome. These outcomes, however, are not necessarily definitive in fixing a person's development irrevocably. One can repair the damage, so to speak, through more positive experiences in later stages of one's life, through experiences that enable one to revisit the challenge perhaps now more intentionally. (Sergiovanni et al., 2014, p. 54).

If our pre-service teachers come to the teacher education program with a fear of math and dashed creativity, we can help repair the damage by allowing them to re-examine those challenges with the support they need in order to have positive encounters with the mathematical concepts. This will help the pre-service teachers not to perpetuate their own fears and dashed creativity to the next generation of students! This may be met with some resistance, but it is possible to change the pre-service teachers' minds, but the pre-service teachers' tendencies to fall back on what they know and are comfortable with is a little more of a challenge (Ball, 1988). If we use the framework of knowledge, attitudes, and beliefs that the pre-service teachers come to a teacher education program with, we can begin to help pre-service teachers see the needs for positive change in mathematics education, instead of continuing to teach the way they were taught.

As shown in Figure 1, one can see the rich connections between the major components of a theoretical framework that maps the complexity of mathematics

education (van der Sandt, 2007; Ernest, 1989; Stipek, 2001; Ball, 1988). Knowledge, attitudes, and beliefs are all important parts that influence the in-service and pre-service teachers' classroom practice. This in turn impacts the learners in the classroom. Their knowledge, attitudes, and beliefs are also affected by what the teacher brings into the classroom.

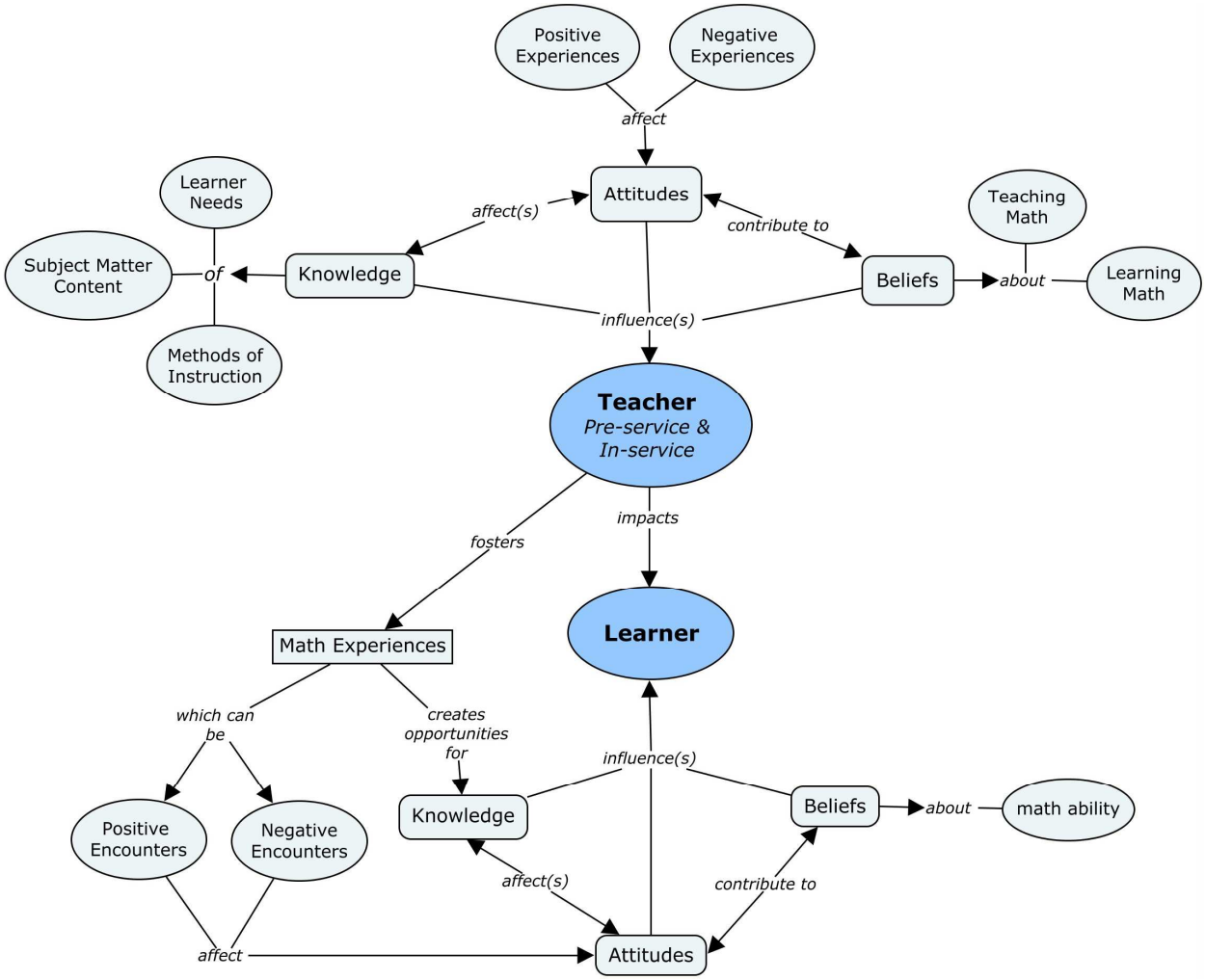

Figure 1. Theoretical Framework for Mapping the Complexity of Mathematics Education.

When evaluating how to improve teacher education programs in the area of the preparation of pre-service teachers for mathematics education, one must consider all of the components making up the theoretical framework of mathematics education. Deborah Loewenberg Ball (1988) expresses the importance of investigating pre-service teachers' "knowledge of and about mathematics, ideas about mathematics teaching and learning, and feelings about oneself in relation to mathematics" (p. 42) when attempting to understand the elements that comprise the framework of the pre-service teachers who are entering a teacher education program in mathematics. Van der Sandt et al. (2007) recommend that the courses in the mathematics education field "encompass elements to improve knowledge (subject content, pedagogy (Quinn, 1998) and curriculum knowledge) but also make teachers and prospective teachers aware of their own beliefs and attitudes as well as the role and impact of their beliefs and attitudes towards mathematics, learner characteristics and the teaching and learning of mathematics within a specific social context" (p. 349).

As one can see, there is a significant value in helping pre-service teachers understand the interactions between their mathematical knowledge, attitudes, and beliefs in a teacher education program. For positive change to take place in mathematics education, one must not continue down the path that proves to be ineffective. We must learn from the past and make the appropriate changes in order to see greater success in mathematics education and students reaching their fullest potential. Pre-service teachers' prior experiences, whether positive or negative, are valuable and can be used for transformative practice so that the weaknesses in the

mathematics education encounters pre-service teachers experienced are not perpetuated to their future students.

CHAPTER 3

METHODS

"Too much time was spent on procedures & memorization. This has put me at a disadvantage because I may be able to solve a problem, but not understand 'why' it works" (Survey Response, December 10, 2015). This is a very revealing statement made by a pre-service teacher while reflecting back on her prior experiences in K-12 math education during this study. This pre-service teacher feels her K-12 mathematics education experiences did not set her up for success, but instead put her at a disadvantage due to the primary focus of her mathematics education being on procedures and memorization. Upon reflection, she realizes that she does not truly understand the underlying concepts of the mathematical principles she was taught.

Why is this important? If pre-service teachers do not have mathematical conceptual understanding, they will not be able to teach mathematical concepts to their students. One cannot teach what one does not know. If this pre-service teacher enters college at a disadvantage in the area of mathematics education, then her students are more likely to enter college at a disadvantage also - unless there is a substantive change during her teacher education preparation. As stated previously, the purpose of this study is to examine the perceptions of pre-service teachers with regard to their past experiences in K-12 mathematics education and their plans for how they will teach math in the future in order to see if the pre-service teachers are planning on teaching the way they were taught or if they plan on making a positive change in mathematics education. Does the teacher education program influence pre-service teachers' perceptions in a way that positive change is initiated in the field of mathematics education?

Participants

This study uses a targeted sample of 38 undergraduate students who were enrolled in a CI 388 (Introduction to Math Content and Methods, P-4) or CI 389 (Introduction to Math Content and Methods, 4-8) math methods course during the Fall 2015 semester in the Curriculum and Instruction department at Southern Illinois University Carbondale. The CI 388 course focuses on mathematics content and methods for teaching Pre-K through 4th grade. A developmental progression of concepts and skills are covered in the math content ranging from counting and cardinality to fractional reasoning and geometry. The CI 389 course focuses on mathematics content and methods for teaching 4th through 8th grade. A developmental sequence of math concepts and skills are covered in the content ranging from number systems and algebraic thinking to probability and statistics. Both of these math methods courses are aligned with the Common Core State Standards.

I was able to observe and work with the majority of the students in this study on a weekly basis over the course of the Fall 2015 semester and am continuing to work with several of them during the Fall 2016 semester. Table 1 below gives the genders, college levels, and majors of the sample group.

Table 1

Participant Background

Gender		College Level				Major			
Male	*Female*	*SO*	*JR*	*SR*	*GM*	*ELED*	*SPED*	*ECHC*	*CI*
4	34	3	13	21	1	26	7	4	1

Data Collection

The methods used in this study are rooted in action research (Mills, 2011; Ferrance, 2000), seeking to understand and further improve an educational practice using an inquiry-based approach in a natural setting. Surveys are used to collect both quantitative and qualitative data, and interviews are conducted in order to have more qualitative data to support and expound upon the quantitative data revealed in the surveys. Pre-tests are given on the first day of the semester to the pre-service teachers in the math methods courses. This existing data of the pre-service teachers' responses and scores help set the stage for this study by showing the level of mathematical conceptual knowledge with which the pre-service teachers began the courses. The existing data, surveys, and interviews work together to create a comprehensive picture of the perceptions and mathematical knowledge of the pre-service teachers.

At the end of the Fall 2015 semester, an anonymous 30-question paper-pencil survey, taking approximately 15 minutes to complete, was administered to the sample group. The survey consists of questions using a 5-point Likert-type scale, with responses ranging from "Strongly Disagree" to "Strongly Agree." Select questions are followed by the open-response question, "Please explain why you chose your answer." There is also one open-response question, which is not connected to a Likert-type scale. The survey questions are a combination of newly designed questions and adapted questions from the Mathematics Attitudes and Perceptions Survey (Lo, Merchant, & Code, 2011), Ohio Pre-service Survey (Rosas & West, 2011), and Student Attitude Survey (Brookstein, Hegedus, Dalton, & Moniz, 2011). The questions on the survey are separated into two parts: (a) questions relating to pre-service teachers'

perceptions of their own K-12 education and (b) questions relating to pre-service teachers' perceptions of how they will teach math to K-12 students in the future.

Do these pre-service teachers plan on teaching the way they were taught or will the math methods courses in the teacher preparation program have influenced their perceptions of how they will teach math in the future? In order to measure this through the survey, the questions on the first part, which relate to past learning experiences, are similar to questions on the second part, which relate to future teaching practices. In addition, there are open-response questions which give participants opportunities to speak about the influence of the math methods courses.

This study also uses a focus group of five pre-service teachers (Female = 4, Male = 1) having varying ability levels with whom interviews are conducted - each interview taking approximately 30 minutes. Each interview participant is assigned a random code that is connected to his or her interview information. The names connected to the codes are kept in a separate secured file from the interview responses in order to ensure anonymity. The questions discussed during the interview are constructed in a way that would help shed light on pre-service teachers' perceptions of their past experiences with mathematics education and how they feel they will teach mathematics to their students in the future. This qualitative data provides a context to themes which emerge from the surveys.

Data Analysis

Analysis of Existing Pretest Data

In order to situate the study of the pre-service teachers' mathematical conceptual understanding, pre-tests which are completed on the first day of the math methods

courses are used as background information. The average scores and free responses from the pre-tests point to gaps in the conceptual understanding among this group of pre-service teachers and the nature and level of their conceptual knowledge upon entering these math methods courses.

Analysis of Survey Data

Once the surveys were administered and completed, the data was compiled and analyzed (a) quantitatively, measuring the prevalence of pre-service teachers' perceptions of their past mathematics learning experiences along with their future teaching practices and (b) qualitatively, exploring trends in the perceptions of pre-service teachers and the influence of past experiences and current math methods instruction. The questions regarding past experiences with learning mathematics have corresponding questions having to do with the pre-service teachers' thoughts on how they will teach mathematics to their students in the future. An exploratory factor analysis was conducted to look into the correlations among the variables covered by the survey. This helps reduce the data complexity and make sense of the data to see if the pre-service teachers' past experiences influence their future teaching practices. The open response questions about the math methods courses were also analyzed in order to see what influence the teacher education program has on the pre-service teachers' visions of their future teaching practices.

Analysis of Interview Data

Upon completion of the interviews, each session was transcribed and the responses were analyzed from each interview and themes which emerged for each question were recorded. In order to test the inter-rater reliability of the themes

discovered, a fellow graduate assistant completing his Ph.D. in education at Southern Illinois University Carbondale recorded the emerging themes he discovered in one of the transcribed interviews, and these themes were compared to the themes discovered in this study to see if they correlate. After inter-rater calibration, the emerging themes for each question were compared with each interview transcription to see if, collectively as a focus group, there are specific emergent themes pertaining to past mathematical experiences and future teaching practices.

The existing data from the pre-tests, the quantitative data from the surveys, and the qualitative data from both the surveys and interviews were all analyzed in light of this study's research questions:

(1) How do pre-service teachers view their past experiences with mathematics during their K-12 education?

(2) What are pre-service teachers' visions of how they will teach mathematics to their students in the future?

(3) Which appears to have more influence on pre-service teachers' perceptions of their own future math teaching practices: their past learning experiences or their current teacher preparation program?

(4) What do pre-service teachers perceive as effective ways of mathematics teaching and learning?

As mentioned earlier, teachers' knowledge, attitudes, and beliefs comprise the main elements of the theoretical framework on mathematics teacher education (Fuentes et al., 2014; Bu et al., 2012; van der Sandt, 2007; Stipek, 2001; Ernest, 1989; Ball, 1988) in this study. These foundational components are considered integral parts

of the analysis process. The framework together with the research questions in this study help shed light on the pre-service teachers' perceptions about mathematics education and teacher preparation.

CHAPTER 4

FINDINGS

"I will likely fall back on what I am familiar with when I first begin teaching, but hope I will not continue to do so as it is unhelpful" (Survey Response, December 10, 2015). This was a comment from a pre-service teacher when asked about whether she would teach math the way she was taught during her K-12 education. This statement stands out as a portrait of the major findings from this study. The purpose of this study was to examine how pre-service teachers viewed their prior experiences with learning math during their K-12 education and compare those views with their ideas of how they felt they would teach math in the future. This chapter will reveal that the pre-service teachers in this study began to realize that the K-12 mathematics education they received did not truly prepare them for what they were encountering in college nor for teaching math at the elementary level in the future, but when faced with the possibility of teaching K-12 mathematics in the future, many revealed that they would probably go back to what they are most familiar with, which is the way they were taught mathematics.

This trend is supported by another statement from a pre-service teacher in this study. When asked how well she felt the teacher education program was preparing her for teaching mathematics in the future, she reflected back on her prior K-12 mathematics education experience and compared it to how she is being taught during the math methods courses in the teacher education program and then responded:

> We memorized facts, and facts were just fine until you put the logic into it. And now they're all in to logic to be able to, I mean explain the beginning to end.

> Well, actually, that should prepare me better, though. Because if I know the root to it, that should, yeah, I think they will equip me in a way that I will be able to do it and because I would understand it more, so yeah. But I still like facts. I like the shortcuts. (Interview, December 9, 2015)

This pre-service teacher shared that she felt good about memorizing facts, but struggled with now having to think about the logic behind the mathematical principles. Would this have been different if she had been exposed to the concepts prior to being asked to memorize the cold mathematical facts? Even though this pre-service teacher realized that she should be better equipped to teach mathematics because she is now learning in her math methods courses that conceptual understanding is more important than the memorization of facts, she still reveals a tendency to fall back on what she knows and that with which she is more familiar. These are just a couple of examples of thematic trends within the data from this study.

Pre-service teachers' knowledge, attitudes, and beliefs all play a part in their preparation for teaching mathematics (Fuentes et al., 2014; Bu et al., 2012; van der Sandt, 2007; Stipek, 2001; Ernest, 1989; Ball, 1988). In order to address the knowledge component, pre-existing data from the pre-service teachers' pre-test scores upon entering the CI 388 (Introduction to Math Content and Methods, P-4) and CI 389 (Introduction to Math Content and Methods, 4-8) math methods courses in the Curriculum and Instruction department at Southern Illinois University Carbondale were used. The pre-tests for these courses measure not only elementary level knowledge, but also the conceptual understanding of mathematical principles that the pre-service teachers possess. The focus of the pre-test questions is to assess the level at which

the pre-service teachers understand the concepts behind elementary level mathematical principles. In order to do this, students are not only asked to solve math problems, but they also need to show or explain why the mathematical principles of the elementary concepts work. The average score from 101 pre-service teachers on the CI 388/CI 389 pre-test from Fall 2014 through Fall 2015 was 46.8%, with 100% representing all mathematical concepts being fully understood by the pre-service teacher. The average score of the pre-service teachers in the sample group from this study (those taking CI 388 and CI 389 during the Fall 2015 semester) was 49.4% on this pre-test. From this data, one can see that on average, pre-service teachers do not enter math methods courses with the proper foundation of conceptual understanding of mathematical principles. These findings are consistent with findings of the study conducted by Rosas & Campbell (2010) who found that in one group of pre-service teachers, the majority of them could only answer correctly 50% or less of the 8th grade level math questions on an Ohio Achievement Math Practice Test.

Why do so many pre-service teachers enter the teacher education program with so limited mathematical understanding? How do we keep this trend from happening? It begins with better preparation of pre-service teachers so that those entering the education field do not perpetuate the lack of mathematical knowledge and conceptual understanding with which they were taught.

The quantitative data collected from the surveys administered and the qualitative data gathered from both the completed surveys and interviews conducted were all analyzed in light of the research questions set forth at the beginning of this study. The findings from the study will be discussed as they connect back and answer each of the

research questions. Both quantitative and qualitative data will be given to support the findings from each research question.

Research Question One

How do pre-service teachers view their past experiences with mathematics during their K-12 education? The emerging trends in the surveys and interviews pointed to many pre-service teachers feeling that their K-12 mathematics education experiences consisted of learning steps, procedures, and formulas that they needed to memorize instead of being taught the concepts behind the mathematical principles. This was also accompanied with feelings of nervousness and oftentimes feeling lost. Many pre-service teachers also felt that their teachers did not provide many varied examples of math problems. In other words, they were mostly taught one way to solve the problems. Unfortunately, many times the feelings from our past experiences impact our future encounters and expectations. This is no different when it comes to math education. Table two reflects themes that emerged regarding pre-service teachers' perceptions of their K-12 math education.

One pre-service teacher shared her struggle with her K-12 math education experience. It was not a pleasant experience for her, but one filled with anxiety that impacted how she views math even today:

> I didn't like it. I was always really nervous to go into math class. Even now, I'm always nervous to come in, because I don't want to be called on because I don't know if I fully understand, and I don't want to make a fool out of myself. I don't know. I've always struggled with math, and I don't know if that's because of the teaching, my teachers, or if it's because I lack the full understanding. I'm not

sure, but I know from experience, I did not enjoy my math education. I did not. It's carried with me, and now, I don't know. It's hard, and it makes it even worse. Even harder. (Interview, December 10, 2015)

This pre-service teacher is not alone. As can be seen in the statistics from table two, with regard to their K-12 mathematics education experiences, approximately 45% of the pre-service teachers from this study agreed that they felt lost and nervous during their K-12 math classes.

Table 2

Emerging Themes from Survey, Part 1

During my K-12 education, overall...	Disagree	Neither	Agree
When I had to complete math problems on my own, I felt nervous.	37%	18%	45%
I oftentimes felt lost in math class.	40%	15%	45%
Math class mostly consisted of facts and procedures that I needed to memorize.	16%	5%	79%
My math teachers explained mathematical concepts ***before*** showing the steps or procedures for solving the problems.	50%	21%	29%
My teachers taught math mostly by explaining mathematical concepts - ***why*** the steps and procedures to problems work.	47%	21%	32%
I felt I learned not only how to solve math problems, but also the concepts behind the mathematical principles.	59%	19%	22%
My math teachers showed lots of different ways to look at the same question	53%	15%	32%

Another pre-service teacher reflected on the possibility of why she oftentimes felt lost in her K-12 math classes: "Because all of the basic concepts build on each other -

I was lost because I hadn't mastered some of the basic concepts" (Survey Response, December 10, 2015). If the conceptual understanding of the mathematical principles has not been mastered, the students cannot move on to the next building block because the foundation that has been laid is not solid.

Why is the conceptual understanding not present in pre-service teachers? Could it be because they mostly learned steps and procedures instead of the mathematical concepts? The pre-service teachers from this study overwhelmingly shared that their K-12 math education consisted mostly of facts and procedures that they needed to memorize. In fact, 79% agreed with this statement about their prior math education experience. That is an alarming percentage. Half of the participants in this study stated that they were given steps and procedures for solving problems before they were ever engaged with the mathematical concepts. Were they taught the concepts or just the steps for getting to an answer? Fifty-nine percent did not feel they were taught the concepts along with how to solve the problems.

It was also revealed that 53% did not feel that their teachers showed them many different ways to look at the same question. If students are only shown one way to solve a problem, they tend to think that is the only way to solve it. Some students may not understand that one way to solve the problem that is shown by the teacher, so multiple ways of showing the same problem is vital to reach every student. One pre-service teacher explained this in his statement about why teachers need to know multiple ways for the mathematical concepts:

> I know one thing that I've already discovered in my placements, that students learn differently, so you might explain it one way and some students might get

that, but then you have to have another way to bring about that material so that the other students can understand that material also. (Interview, December 10, 2015)

Being exposed to various methods for solving problems is extremely important in the teaching and learning of mathematics. Looking at the percentages in Table two above that reflect how the majority of students were taught mathematics in their K-12 education using memorization, facts, and procedures and not varied methods for solving problems is extremely disturbing. Even though the numbers are disconcerting, they help provide a background as to a possible reason for why the average pre-test score on this group of pre-service teachers was a 49% out of 100%. One pre-service teacher reflected back on her own K-12 math experience: "You were taught to bring down the zero, I never knew why I brought down. You know? You were just taught to do it, and you got the right answer" (Interview, December 10, 2015).

The majority of the pre-service teachers felt they were mostly taught formulas, facts, and steps to solving problems and that they were not taught why the steps work or what the underlying concepts were for the mathematical facts they were given. "We are taught facts. We memorize facts, and now that I'm doing this, it's like, 'Oh, now I really have to know where these facts are coming from,' and that's kind of hard" (Interview, December 9, 2015). Being taught facts through memorization puts them at a disadvantage because they come into the teacher education program without the needed mathematical foundation.

Like I've said, formulas I'm really good at, but just the concepts and the reasons why I'm doing something, I'm not very confident on because I wasn't taught that

or we didn't necessarily focus on why we were doing something - more as let's do this and this is how you do it. (Interview, December 10, 2015)

This reflection from a pre-service teacher about her own past experience in K-12 math education shows a tremendous problem in the mathematics education system. The lack of conceptual understanding also impacts the confidence level of the pre-service teachers. If they were not taught the concepts, how will they begin to teach those concepts to their students in the future?

Research Question Two

What are pre-service teachers' visions of how they will teach mathematics to their students in the future? The trends that emerged from the surveys were very strong. Both the surveys and interviews revealed that the pre-service teachers envisioned themselves focusing more on teaching concepts than steps, procedures, and facts that the students need to memorize. They felt that conceptual understanding of the mathematical principles was extremely important for their students. Table three gives the overview of the results that relate to this section of the study.

When it came to deciding if the pre-service teachers' future mathematics teaching would consist mostly of facts and procedures that the students should memorize, none of the pre-service teachers agreed that this is how they would teach. Why? Could it be that they realized how much the experience for them did not prepare them? None of the pre-service teachers felt that teaching by facts and memorization was a good way of teaching.

I know what to do step A to step B, but...I want to be able to tell them why do we do that. There's times where I definitely have to think, "Okay, why are we doing

this step?" Because we don't just need to tell them, "Okay, just do it." There needs to be a reason behind it. (Interview, December 10, 2015)

The majority of the pre-service teachers agree with this idea. Seventy-one percent agreed that it is more important for their students to understand the mathematical concepts than just memorizing the facts and procedures, with 79% sharing that when they teach mathematics in the future, they will focus mostly on the concepts behind the mathematical principles that their students should know.

It's important to again understand why you're doing what you're doing and why it works instead of, "Okay, I know that I need to multiply this and then add a zero and then." A lot of times they don't know why they're doing it. And on some problems, they'll multiply correctly and they won't put the decimal in the right place. And I think it's important to go back and show them why you put the decimal in this place. (Interview, December 10, 2015)

Students need to not only know the "why" behind the "what" and "how" of mathematical concepts, but they need to remember to ask themselves if their answers make sense. Sense-making is an important concept for students and is one of the first standards for mathematical practices in the Common Core State Standards for Mathematics (CCSS, 2016; NCTM 2000). As the pre-service teacher stated above, if a student has a decimal in the wrong place, they need to know why the decimal goes where it does. They should be able to look at their answers and know whether or not those answers are reasonable. This comes back to conceptual understanding of the mathematical principles.

Table 3

Emerging Themes from Survey, Part 2

When I teach math to K-12 students in the future...	Disagree	Neither	Agree
I feel it is more important that my students know the procedures for solving problems than the reasons why those procedures work.	71%	8%	21%
I will focus mostly on the math facts and procedures that my students should memorize.	90%	10%	0%
I will focus mostly on the concepts behind the math facts and procedures that my students should know.	11%	10%	79%
If I don't understand the "why" behind a math concept, I will research the concept before I teach it.	0%	0.0%	100%
If a student answers a question using a procedure that I am not familiar with and that is different than my answer key, I will analyze his or her response to see if it is mathematically sound.	0%	5%	95%
I will encourage my students to ask questions, even if I don't feel comfortable with the math concept.	0%	5%	95%
I think it would confuse my students if I show multiple ways to solve a problem.	81%	16%	3%

There may be times when a math concept unfamiliar to the teacher may arise during a math lesson. What will the teacher do in these cases? Ninety-five percent of the participants in this study agree that even if they don't feel comfortable with a math concept, they will still encourage their students to ask questions and try other methods of which they will analyze to see if the students' thinking is mathematically sound. In addition to this, 81% feel it would not be confusing for their students if they showed various ways of solving problems. Unexpected situations and unfamiliar concepts may be intrinsic and critical components of an inquiry-based class. It is therefore vital for

teachers to be as prepared as possible to teach mathematical principles for conceptual understanding in their day-to-day lessons. This is reflected when 100% of the pre-service teachers from this sample group shared that they will take the time to discover the "why" behind a concept before they teach it if they do not already understand it.

Conceptual understanding must not be taken for granted. If a student is able to get a correct answer following all of the steps they were taught, does that mean the student truly understands the mathematical concept? One pre-service teacher uses her own experience to explain why getting a correct answer does not mean the student understands the concept:

> Just because a kid gets the answer right and it's based off the formula doesn't truly mean they understand, because I know I know all the formulas, I can do the problem, but I don't necessarily know why they work or how they work. (Interview, December 10, 2015)

This is a very vulnerable and honest statement. Mathematics is more than just plugging numbers into a formula. The formulas have meaning, and that meaning is important for the students to understand. These pre-service teachers envision themselves teaching mathematics in a conceptual way, showing their students multiple ways to solve problems, and researching the math concepts they do not understand prior to teaching. The survey data in this study show that the pre-service teachers have very strong feelings about how they perceive they will teach math to their students in the future. If these perceptions become a reality, their students will have a very rich mathematics education! These positive perceptions of their future teaching practices

can be used as a springboard to help the pre-service teachers continue to grow as educators of mathematics.

Research Question Three

Which appears to have more influence on pre-service teachers' perceptions of their own future math teaching practices: their past learning experiences or their current teacher preparation program? It is evident through both the surveys and the interviews that the teacher education program has a significant impact on pre-service teachers. These students' perceptions of how they plan on teaching math in the future have definitely been influenced by their current teacher education program. The table below shows the trends of how they were taught mathematics as compared to how they plan on teaching mathematics.

Table 4

Emerging Themes from Survey, Part 3

Pre-service teachers were taught...	Pre-service teachers plan to teach...
Focusing on the facts, procedures, and memorization (79%)	Focusing on the concepts behind the facts and procedures (79%)
Steps and procedures before concepts (50%)	Concepts before steps and procedures (79%)
Using very few examples and methods for solving the same problem (53%)	Using multiple examples and methods for solving the same problem (81%)

These statistics reflect that there is a trend that the pre-service teachers do not plan on teaching the way they were taught. A bigger question, though, is whether those perceptions will be a reality when they get into the classroom and begin teaching

mathematics to their students. When discussing what type of teaching is best in order for students to truly have mathematical understanding, the teacher education program appears to have more of an influence on pre-service teachers' perceptions than their past experiences in K-12 mathematics education. What happens when they get out of the college classroom environment and are more in their field placements in the K-12 classroom?

Field experiences emerged as one of the themes from the interviews that play a vital role in shaping pre-service teachers' vision for mathematics teaching. One pre-service teacher stated that pre-service teachers "need to have more of a field experience when it comes to a methods class" (Interview, December 10, 2015) in the teacher education program.

> I think that where we learn the most is still more and more in our placements, and you're actually in the field...I've learned so much more when I'm in the field, talking with my teacher, watching students work, instead of sitting in the classroom and talking about it in the classroom. You learn way more in the field. (Interview, December 10, 2015)

This does not mean that the college classroom instruction during the teacher education program is not important. It prepares the students for what they will encounter in their field placements. Another pre-service teacher summed it up well:

> I feel like in the classroom, they give you ideas, and now it is focused more on hands-on. And that's good, so we kind of get an introduction to it and ideas we can do, but then when we take it into the [school] classroom, we can see how it really works. We can peer-teach all we want, but it's still not the real thing. As

much as we try to answer like they do, we can't. We tried, but it doesn't work quite the same way. But I feel like they've prepared us as much as possible inside the [university] classroom. (Interview, December 10, 2015)

Since these pre-service teachers, on average, score 49% on the pre-test measuring elementary level mathematical concepts, they will be faced with a harsh reality when they enter the classroom. Most of them were not taught the math concepts, so it will take more preparation time for them to be able to teach the concepts because they will need to familiarize themselves with the conceptual understanding that is lacking prior to entering the K-12 classroom.

I feel like I know the process, but I feel like I have to kind of sometimes, especially with Common Core, kind of re-teach myself a little bit and review over it and think, "Okay, now why do they do this?" Because you know I wasn't necessarily taught that through elementary and high school. So I do have to kind of go over it and think, "Okay, now, if students ask me why, am I able to answer that?" (Interview, December 10, 2015)

Notice the wording the pre-service teacher used: "...if students ask me why." Yet 79% claimed they would teach concepts before the facts and procedures of the mathematical principles. Should there be a question of "if" the students ask about the "why," or should teachers be presenting the math concepts from the beginning so the students gain conceptual understanding? The data reveal that the majority of the perceptions of these pre-service teachers lean toward teaching for conceptual understanding, but the survey comments and interviews shed light on the dilemma that perceptions may not always be acted upon in the day-to-day teaching experience.

This tension between perceptions and actions is very real. One pre-service teacher shared her struggle between knowing what she should do and knowing what she will probably do: "I know what my initial response to teaching math will be (procedural) and that I need to become comfortable with explaining and focusing on the concept instead of the steps to reach the correct answer" (Survey Response, December 10, 2015). Another pre-service teacher's very honest reflection that was mentioned in the beginning of this chapter sums this battle up well: "I will likely fall back on what I am familiar with when I first begin teaching but hope I will not continue to do so as it is unhelpful" (Survey Response, December 10, 2015).

These pre-service teachers have come into the teacher education program with a shaky mathematics foundation, but they do see the need for change in the field of mathematics education. Table 5 reveals that only 15% of the pre-service teachers plan on teaching mathematics they way they were taught and that 68% believe that the math methods courses they have taken so far in the teacher education program have influenced how they will teach math in the future.

Table 5

Emerging Themes from Survey, Part 4

When I teach math to K-12 students in the future...	Disagree	Neither	Agree
I will teach math the way I was taught during my K-12 education.	69%	16%	15%
I think the math methods classes I have taken so far have influenced how I will teach math to elementary students in the future.	24%	8%	68%

This does not mean that every participant believed they should teach differently from their own experiences. One student made the following remark in an interview:

> I don't get the concept why I have to explain everything to death. I have a hard time with that anyways. Explaining is my weakest. I just want to go to the point. If I could just go find the shortcut and go to the point - that's how I was taught - was always finding the shortcut to get it, make it, as long as it works. (Interview, December 9, 2015)

This pre-service teacher revealed that she has a hard time with explaining concepts. This is very concerning since she is training to be an elementary school teacher. Explaining concepts is foundational in the field of education. What is even more concerning is that after admitting that explaining is her weakness, she shared that she just wants to get to the answer by using shortcuts. What type of mathematics education would school children receive from this type of instruction?

There will be times when the pre-service teachers encounter difficulties. How will they handle those situations? Will they retreat back to what they know or will they take the challenges and not only learn the concepts they need to know in order to teach their students, but also learn how to explain those concepts in a way their students can understand? One participant in this study shared her personal struggle:

> Some things, I'm like, "Oh yeah, I could explain that really, really well." Other things, I know what I want to say, and I know how to get there, but I don't know how to tell somebody else. Or even on paper, it makes sense in my brain, but I cannot make it make sense to anybody else. But again, I think that goes back to

not having the best math experience as I was transitioning into high school. (Interview, December 8, 2015)

In the field of education, one has to be able to communicate and explain concepts to the students. This is a vital part of teaching. The weak mathematical experiences have made a negative impact on many pre-service teachers, but the teacher education program plays an important role in impacting teachers before they enter the education field.

Research Question Four

What do pre-service teachers perceive as effective ways of mathematics teaching and learning? In addition to teaching concepts and not just facts and procedures, the major themes about effective teaching methods that came from the surveys and interviews were using real-world scenarios while teaching, creating a classroom where students are engaged, providing hands-on activities, and explaining concepts in multiple ways. In order to discover the trends that pre-service teachers believed were effective teaching methods for mathematics, the data collected from the questions relating to this research question were extended responses, so the data are mostly qualitative in nature, with the exception of the responses regarding teaching concepts versus teaching math facts and procedures that were referenced in the last section.

> I remember the S*** book and how it was just black and white and this step to this step to this step, and I think it's amazing with Common Core now and how we're being creative with applying our math concepts where a lot of it I think when I went through math, it was more, "Okay, here's your numbers. Here's the

next step you go to," instead of doing projects with it and applying it to real-life situations. (Interview, December 10, 2015)

This pre-service teacher sees the value of using real-life situations in mathematics so that the students understand math is not just a stand-alone subject in school, but it can be applied to every area of life. This was an emerging trend from the survey responses and the interviews. Although, one person interviewed did mention the struggle she encountered while watching a teacher attempt to teach long division using a different method than she had been taught growing up:

> These kids could not understand it. They couldn't grasp the cues and then this and then this and then this, so finally she said, "Here, let me show you this way," and she long divided the way we were taught in school. And they were like, "Oh!" At that point, do I go back to the Common Core way of teaching this or do I stick with this? Because I'm supposed to be teaching Common Core, but they don't understand it. So do I teach them the way I was taught where they understand it, or do I try and get them back on this? Because a lot of kids, it's hard for them to understand it and it's hard for the parents to understand it.

This pre-service teacher mentions that the students couldn't "grasp the cues" and "then this and then this and then this." The explanation of this situation sounds more as if the teacher was still trying to teach a mathematical concept by giving steps. Conceptual understanding is not taught by memorizing steps and procedures, but if the teacher does not have a grasp on the conceptual understanding herself, it may be the way that teacher would attempt to explain the problem because it is that with which she is most comfortable and familiar. When the teacher decided to teach long division

using the steps she knew, the pre-service teacher said the students could then understand it. Is it possible that the students understood because the teacher felt stronger in explaining the process she was taught than in explaining the underlying concept that she may or may not have fully understood? If one does not understand a concept, it will be quite difficult, if not impossible, to be able to explain that concept in a way that a child can understand.

The situation observed by this pre-service teacher also reveals that this pre-service teacher may see the Common Core not as a set of high standards which seek to elicit conceptual understanding from students, but as a specific way to teach the mathematical concepts. The Common Core is set forth as a set of standards, not a specific teaching method. One pre-service teacher stated, "In order to teach math well, I need to understand Common Core math before I graduate" (Survey Response, December 10, 2015). This student does not need to understand "Common Core math;" she needs to have conceptual understanding of the mathematical principles and practices. This is more likely to occur when students can relate the concepts to situations they experience in the real world.

> I think everything in math has a way to come back into real life whether it be just shopping in general, like with money or the clothes you wear or even the tiles in the floor like we've learned. It comes back into life. And I also think relating it back helps the child learn more because I know when I actually have real-life scenarios, I'm like, "Oh, I get that." That helps me. I think you can always relate stuff back to a child's life. (Interview, December 10, 2015)

Mathematical concepts that have meaning to a student are not only effective with smaller children, but also with adult learners! Engagement was also a theme that emerged as an effective way of teaching mathematics to students. One pre-service teacher shared that keeping "them engaged and moving versus just having them sit there and memorize the answer" (Interview, December 8, 2015) is more effective when teaching and learning mathematics.

> I think having them do projects where they're getting to be engaged and most of the time letting them work with each other so that way it's not always the teacher that's explaining to them the material. They can bounce ideas off of each other in order to maybe come up with their own ways to solve problems. (Interview, December 10, 2015)

Engagement is extremely important in any area of education, but it tends to be alarmingly forgotten in the area of mathematics, especially when math is taught using facts, procedures, and memorization. Engagement can be fostered through using real-world scenarios, having hands-on activities and projects, and teaching using multiple ways for solving problems. As one can see, engagement connects well with all of the themes mentioned for effective ways of teaching math.

Hands-on experiences coupled with project-based learning that uses real-life scenarios is extremely impacting.

> We recently, in my class today, did a project where they planned Thanksgiving dinner and decided how many it could serve, how much it would cost, and I think it really helped them understand, like we were talking about, the real world, but

then actually getting to do the operations and things like that. (Interview, December 10, 2015)

This was a powerful example of a real-world scenario where the students were able to apply the mathematical concepts they had learned to a situation with which they were familiar. They were also able to experience the value of collaboration with other students during the project.

I think one of the main things I've gotten a lot from is more of, we've touched on it, the project-based learning and the hands-on experiences. Even in the classroom and in my field experiences, I feel like my students learn the best through that. (Interview, December 10, 2015)

Hands-on experiences and project-based learning that is rooted in real-world situations is extremely powerful for students when learning mathematics (Curtis, 2001; Laboy-Rush, n.d). The pre-service teachers who are currently in field assignments see how important these experiences are to students. Since children are different and have unique ways of learning, a teacher must be able to explain mathematical concepts in various ways so that each child understands. One pre-service teacher mentioned this in her interview: "You have to have multiple angles to be able to teach and to reach the whole class because everybody does not learn the same way" (Interview, December 9, 2015). This idea was also supported by another pre-service teacher during his interview.

...having multiple ways to bring about the material cause I know one thing that I've already discovered in my placements, that students they learn differently, so you might explain it one way and some students might get that, but then you

have to have another way to bring about that material so that the other students can understand that material also. (Interview, December 10, 2015)

Showing a variety of ways to solve problems as an effective way for teaching mathematics was a theme that emerged from both the interviews and surveys. As was mentioned previously in this chapter, 81% of the pre-service teachers in this study supported the idea of showing multiple ways to solve a problem. They did not feel it would confuse their students, but that it would be helpful for the students to see various methods for solving a problem. Using various examples and methods, providing hands-on activities, applying mathematical concepts to real-life situations, and engaging students in the math class are all considered by this group of pre-service teachers as effective methods for teaching mathematics.

Factor Analysis

Tables 6a and 6b (separated into two tables due to space) show the exploratory factor analysis that was conducted, which revealed five major constructs: (1) math teachers' understanding, (2) math feelings and confidence, (3) pedagogical tension between facts and meaning, (4) student-teacher interactions, and (5) prior math learning experience. The factor analysis helped reduce the complexity of the data in this survey. The major components discovered support the findings revealed through the surveys and interviews.

The first construct brings to light the importance of math teachers' understanding of the concepts they are teaching. If they have a deep conceptual understanding of the mathematical concepts, they will be able to offer many various examples and methods

for solving the same problem. The level of a teacher's understanding of mathematics impacts the learning opportunities made available to their students.

Table 6a

Factor Analysis Components, Part a

Rotated Component Matrix[a]					
	Component				
	1	2	3	4	5
During K-12 education...					
Level of confidence	.541	.305	-.211	-.025	.178
Level of nervousness	.480	.698	.008	.220	-.026
Encouragement of questions	.483	.236	-.012	-.611	.161
Teachers' answers to questions	.511	.521	-.048	-.057	.128
Focus on memorization	.591	-.266	-.085	-.131	.371
Explanation of concepts before procedures	-.057	.317	-.051	-.274	.719
Teachers' acceptance of other methods	.231	-.226	-.021	.152	.792
Focus on concepts	.387	.062	-.200	-.184	.634
Teachers' use of various examples	.707	.007	.053	-.272	-.049
Teachers' conceptual understanding	.711	.129	-.318	-.067	.231
Teachers' expectation of students	.079	-.450	.214	.150	-.358
Level of feeling lost	.422	.672	-.095	.183	.290
Learning of concepts with solving problems	.505	.402	-.094	-.153	.315

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 14 iterations.

Table 6b

Factor Analysis Components, Part b

Rotated Component Matrix[a]					
	Component				
	1	2	3	4	5
When teaching math to K-12 students...					
Level of confidence	-.082	.736	-.120	-.167	-.082
Importance of procedures	.562	.032	.194	.232	.014
Encouragement of questions	-.020	-.119	.205	.273	-.057
Focus on memorization	-.199	.072	.683	.054	-.044
Focus on concepts	.050	-.112	.464	.352	.471
Expectation of students	.666	.044	.134	.201	-.044
Researching concepts	-.308	-.209	.425	.457	.078
Use of various examples	-.151	.479	.592	.181	-.202
Aim of in-depth study	.036	-.309	.725	-.190	-.054
Explanation of facts before concepts	.056	.294	.135	.064	-.108
Aim of comprehensive coverage	.138	.430	.347	-.100	.297
Analyzing student responses	.046	.234	.214	.739	-.022
Teaching of steps for unfamiliar concepts	.172	.095	.684	.199	-.079
Teaching the way previously taught	-.568	-.174	.149	.561	-.216
Influence of math methods courses	.144	.124	-.162	.683	-.023

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 14 iterations.

Math feelings and confidence was also a major construct. The feelings connected to a student's math experience affect his or her confidence level. If students feel nervous when completing math problems and have a sense of feeling lost during math class, their confidence levels drop. But as students have positive encounters with math and feel comfortable in their understanding, they gain more confidence. Their levels of confidence derived from their mathematics experiences impact their levels of confidence in teaching mathematics.

There is a pedagogical tension between mathematical facts and meaning. Pre-service teachers felt they need to teach math concepts and not just facts, but when faced with a lack of background knowledge in conceptual understanding, they acknowledged that they will more than likely fall back on what they know and understand, which is procedural knowledge. This is a very real tension that pre-service teachers feel. They know how they should teach, but because most of them were not taught that way and do not have the conceptual foundation in mathematics, it is difficult for them to overcome the gap in conceptual understanding in order to teach in a way that their students will be exposed to concepts instead of only procedures to memorize.

Student-teacher interactions is an important construct when it comes to mathematics education. How a teacher interacts with student questions affects how that student will respond to struggles in mathematics in the future. A teacher who invites questions and is willing to analyze a student's method for solving a problem, even when that method is different than the one taught by the teacher, will encourage discovery learning and help students experience genuine mathematical reasoning. Students need to be able to ask questions and allowed to use various methods for

solving problems in order to show their conceptual understanding. How a teacher responds to the student in these situations is a key to opening the door for future success and inquiry learning.

The prior math learning experiences of pre-service teachers, whether positive or negative, impact how they will teach mathematics in the future. The math methods courses in a teacher education program help pre-service teachers realize the need for conceptual understanding, but their prior math learning experiences play a major role in how they view mathematics, their attitudes toward mathematics, and their level of knowledge and conceptual understanding in mathematics. Pre-service teachers bring with them to their future classrooms their own prior math learning experiences, whether those be positive or negative, and they have an impact on future students.

Limitations

Using both quantitative and qualitative data for this study helped strengthen the data collected. Since responses to the questions were primarily based on the pre-service teachers' perceptions, though, there could be an issue of whether the surveys were accurate indicators of their performance in real classroom teaching. In order to elicit as truthful responses as possible, the surveys were completely anonymous and no identifiable data was included in the survey, but the trustworthiness of the responses is still a possible threat to internal validity. This aspect coupled with each participant bringing with them different background experiences in K-12 math education adds a possible subject characteristics threat (Fraenkel & Wallen, 2006). When attempting to gather data on student experiences and perceptions, though, this is a threat that must be considered.

In order to address a testing threat to internal validity, the survey questions mostly consisted of adapted questions from the Mathematics Attitudes and Perceptions Survey (Lo, Merchant, & Code, 2011), Ohio Pre-service Survey (Rosas & West, 2011), and Student Attitude Survey (Brookstein, Hegedus, Dalton, & Moniz, 2011). In order to minimize the testing threat for the questions that were newly designed, the survey and interview questions were both reviewed by professors at Southern Illinois University Carbondale and Arkansas State University. No validity problems with the survey or interview questions were discovered. The Cronbach Alpha for this survey is .727.

Factor analysis is typically conducted on a larger sample; therefore, the factor analysis used in this study was an exercise in methodology. The survey was not homogeneous, but measured various themes, which could have affected the factor analysis results. In spite of the obvious limitations, the factor analysis did reveal the five major constructs that are plausible in the context of elementary teacher education, to be further investigated on a large sample.

The sample population for this study was not large and focused on a group of pre-service teachers in a specific program at one university. With this being the case, the findings are meaningful and informative with respect to this group of pre-service students, but would not be able to be generalized beyond this specific sample group. The findings from this study do bring to light some interesting perceptions and ideas from the pre-service teachers that would be valuable to investigate among a larger population especially in the era of new standards and assessment initiatives.

CHAPTER 5

CONCLUSION

"I feel more confident in the things I'll have to teach. It's the information after that I'm lost to. If a child is ready for more [math concepts beyond what I understand], I can't help because I don't know it " (Survey Response, December 10, 2015). This response is from a pre-service teacher who was reflecting on the influence of the math methods courses she has taken so far in her teacher education program. This is a struggle that many pre-service teachers are facing. The opportunities to explore mathematical concepts while in the math methods courses of their teacher education program help the pre-service teachers build confidence in understanding those concepts, but what do they do when they encounter concepts they do not understand?

The purpose of this study was to explore the trends in pre-service teachers' perceptions of their prior experiences in K-12 math education and their ideas for how they will teach mathematics in the future. In doing this, we set out to investigate how those past experiences influence their perceptions of their own future teaching of mathematics as compared to the influence of their teacher education programs and what the pre-service teachers consider as effective methods for teaching and learning mathematics. This study revealed that when pre-service teachers are exposed to their own lack of conceptual understanding of mathematical principles and have an opportunity to reflect on their past experiences with K-12 mathematics education, they tend to realize that they were taught primarily how to solve problems by applying steps and procedures they were taught to memorize. Upon discovering how they were taught and the level of mathematical competency it has provided for them, many began to

reveal feelings that their K-12 math experiences were not positive with regard to learning and understanding mathematical concepts. When this connection is made, pre-service teachers come to the realization that there is a need to change the way students are being taught and how they are learning mathematics. The pre-service teachers in this study overwhelmingly stated that they do not plan on teaching the way they were taught.

Unfortunately, there is a struggle and tension between knowing what is the better way of teaching mathematics and feeling uncomfortable performing that task (Ball, 1988; Fuentes et al, 2014; Rosas et al., 2011). Pre-service teachers who revealed that they did not want to teach the way they were taught also shared that they will likely fall back to that with which they are most familiar. How do we keep this from happening? Exposing pre-service teachers, as painful as it might be, to what their level of conceptual understanding is in the area of mathematical reasoning is the beginning and proved to be effective in this study. If this happens early enough in their teacher education programs, there are more opportunities to help those students face these difficult struggles, but this time with the support they may not have had during their K-12 mathematics education experiences.

It is important to not only help pre-service teachers students recognize their need for conceptual understanding, but also provide the necessary tools and support system for them to embark on the road of learning the concepts that underlie the mathematical principles they have memorized. When pre-service teachers have positive encounters with meaningful mathematics and appreciate the conceptual nature of mathematics, they are more likely to continue to work on this area of professional development.

When this occurs, it sets the students up to know that when they don't understand a concept that they have to teach, there are resources out there to help them learn the concepts, if they are willing to take the time to seek out those resources.

Meaningful math experiences are extremely important for both K-12 math education and pre-service teacher education. The value of meaningful and sense-making mathematics is explicit in the new education reform and standards. We as a society have proclaimed in our standards (educational values) that we desire for students to possess mathematical or quantitative literacy. It is important for students to gain conceptual understanding of the mathematical principles and not just follow a set of procedures to compute an answer.

For example, how many students have been taught the order of operations simply by being told to memorize the mnemonic Please Excuse My Dear Aunt Sally? Is this mnemonic harmful to students? I suggest that it depends on how it is taught. If there is no context or meaning to the order of operations, then it can be very harmful to future conceptual understanding and mathematical literacy. In fact, the lack of context is one reason why many students do not correctly apply the order of operations. Math tells a story. When solving a problem, it is not simply a group of numbers that need to be computed. The numbers have meaning, and apart from the context, it is difficult for students to understand why they are performing the given operations.

I was recently working with a group of in-service teachers who had been given a story, which involved fractions. Using modeling and the context of the narrative, the teachers used mathematical principles in a way that made sense to them in order to solve the problem. Not all of the teachers' methods looked the same, but they were

accurate. In order to build on the methods used in problem solving, I then asked the teachers to create a mathematical expression that represented the story and how they chose to solve the problem. When the mathematical expression was created, I asked them if the expression correctly reflected what happened in the story. They realized that parentheses needed to be inserted in the expression in order to represent that subtraction happened in the story before any other operations were performed. The parentheses simply told what happened first in the narrative they were given. There was a context as to why there were parentheses in the mathematical expression, and it was not just an algorithm or mnemonic that the students needed to memorize in order to compute an answer.

The knowledge, attitudes, and beliefs of pre-service teachers are all important components to consider when investigating how to prepare students to teach mathematics (Fuentes et al., 2014; Bu et al., 2012; van der Sandt, 2007; Stipek, 2001; Ernest, 1989; Ball, 1988). In keeping with this theoretical framework, we looked at the entry level of mathematical competency of the pre-service teachers in our study, the attitudes toward their past experiences with mathematics education, and their beliefs for what they considered to be effective methods for teaching and learning mathematics and how they plan on teaching mathematics in the future. Since our study dealt primarily with the perceptions of pre-service teachers, an intervention was not conducted. Without an intervention, this study does not explore the various methods for helping pre-service teachers resolve the tension between their perceptions of knowing what is considered good teaching and their comfort levels of putting into action those methods within their classrooms. Many of these pre-service teachers have not

had prolonged opportunities to face this struggle in the classroom with K-12 students. They see the need for conceptual understanding, but have not had the opportunity to face that inward tension when they do not understand the concept for themselves but know their students need to gain the conceptual understanding.

With pre-service teachers being held to a higher level than ever before due to the new requirements of edTPA (Teacher Performance Assessment), which applies a process that resembles National Board Certification for teachers (American Association of Colleges for Teacher Education, 2015; Stanford Center for Assessment, Learning, & Equity, 2015), this study has significant implications. Why are pre-service teachers struggling in the area of mathematics education and how can teacher education programs help them? Along with the high-stakes content and licensure standards for pre-service teacher education, there is a crying need for studies to be conducted on helping pre-service teachers understand their own K-12 schooling experiences and further succeed in the teacher education programs and subsequent K-12 teaching, while they struggle to rebuild the conceptual foundation for school mathematics.

Pre-service teachers bring with them both positive and negative mathematics education experiences (Ball, 1988) when they enter teacher education programs. How can these experiences, whether positive or negative, be used in teacher education programs so that pre-service teachers are fully equipped to enter the field of education and transform educational practices in mathematics teaching? This study looked into the perceptions of pre-service teachers, but how do we move beyond their perceptions and bring about the necessary change in the mathematics education of pre-service teachers? This is an area for future research, building on the research findings.

Interventions in teacher education programs can be developed and opportunities for more field experiences (Stipek et al, 2001; Ernest, 1989; Ball 1988) with trained teacher educators who can help them resolve the tension between their perceptions of how they should teach and their tendencies to fall back on what they know and also help them discover the amount of student learning that takes place through inquiry-based approaches for conceptual understanding (Stipek, 2001; Ball 1988) could yield some interesting results.

This study found that pre-service teachers have positive attitudes toward teaching mathematics for conceptual understanding and not just factual memorization of procedures as many were taught during their K-12 math education. They also voiced the need for more field experiences in their teacher education program, so they can have more opportunities for hands-on experiences in the application of the methods, such as project-based learning and diverse ways of problem solving, that they learn in their courses. Further research can be done on teacher education program improvement by applying the ideas of strengthening quality field experiences, using project-based learning, and providing multiple ways of solving problems in order to see how these suggestions impact teacher preparation and student learning.

In conclusion, there is a need for change in mathematics preparation of pre-service teachers. We do not need more of the same type of mathematics education that is founded upon the memorization of steps and procedures rather than mathematical literacy and deep understanding of what the mathematical principles mean and why those procedures are being performed. If after 13 years of math education, students still do not grasp the basic mathematical concepts and do not have

a solid foundation in mathematical and quantitative literacy, then more time spent memorizing formulas and procedures will not yield a different result. If a type of teaching is not producing the desired outcome, then another type of teaching is required. The statistics of 40% - 68% of college students needing to take a remedial class (American Association of Community Colleges, 2014) reveals that there is a problem in education and continuing the cycle of teaching mathematics the way it has always been taught will not improve these statistics in the future. There must be a change.

This will not be easy by any means. The new standards require in-service and pre-service teachers alike "to stretch beyond their comfort levels, to dig into their content with renewed sense of personal learning, and to examine their professional practices and collaborative professional communities" (Godbold, 2013). Being stretched beyond what is comfortable is obviously going to yield a feeling of being uncomfortable, but if this is what is necessary in order to improve mathematics education and provide quality learning opportunities to students, then it is worth it.

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APPENDICES

APPENDIX A

SURVEY

During my K-12 education, overall...

1. I felt confident that I could learn new math concepts.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

2. When I had to complete math problems on my own, I felt nervous.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

3. My math teachers encouraged me to ask questions.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

4. My math teachers answered my questions in a way that I could then understand the math concepts being taught.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

5. Math class mostly consisted of facts and procedures that I needed to memorize.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

6. My math teachers explained mathematical concepts ***before*** showing the steps or procedures for solving the problems.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

7. When I answered a question using a different method than my teacher taught, my teacher would not accept my response, even if it was mathematically sound.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

8. My teachers taught math mostly by explaining mathematical concepts - ***why*** the steps and procedures to problems work.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

9. My math teachers showed lots of different ways to look at the same question.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

10. I felt my teachers had a deep understanding of the concepts underlying the mathematical principles.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

11. My math teachers expected me to solve problems that were not similar to any example given in class or the textbook, but the concepts had been covered in class.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

12. I oftentimes felt lost in math class.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

Please explain why you chose your answer:

13. I felt I learned not only how to solve math problems, but also the concepts behind the mathematical principles.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

Please explain why you chose your answer:

When I teach math to K-12 students in the future...

14. I will feel confident about teaching math.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

15. I feel it is more important that my students know the procedures for solving problems than the reasons why those procedures work.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

16. I will encourage my students to ask questions, even if I don't feel comfortable with the math concept.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

17. I will focus mostly on the math facts and procedures that my students should memorize.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

18. I will focus mostly on the concepts behind the math facts and procedures that my students should know.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

19. I will not expect my students to solve a math problem that is not similar to any example given in class or the textbook, even if the concept has been covered in the course.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

20. If I don't understand the "why" behind a math concept, I will research the concept before I teach it.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

21. I think it would confuse my students if I show multiple ways to solve a problem.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

22. I will aim for in-depth study of selected topics, even if it means sacrificing comprehensive coverage.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

23. I will teach basic facts and computation skills ***before*** discussing the concepts underlying the mathematical principles.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

24. I will aim for comprehensive coverage, even if it means sacrificing in-depth study.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

25. If a student answers a question using a procedure that I am not familiar with and that is different than my answer key, I will analyze his or her response to see if it is mathematically sound.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

Please explain why you chose your answer:

26. If I don't understand the "why" behind a math concept, and I don't have enough time to research the concept, I will focus on teaching the steps and procedures for solving the problem.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

Please explain why you chose your answer:

27. I will teach math the way I was taught during my K-12 education.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

Please explain why you chose your answer:

28. What do you consider effective methods of teaching math in order to provide greater opportunity for growth in student learning?

29. How many math methods courses have you taken so far *(include the class you are currently taking)*? _____

30. I think the math methods classes I have taken so far have influenced how I will teach math to elementary students in the future.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

Please explain why you chose your answer:

APPENDIX B

INTERVIEW PROTOCOL

1. What do you think you need to know *mathematically* in order to teach mathematics at the elementary level?
2. What do you think you need to know *pedagogically* in order to teach mathematics at the elementary level?
3. How do you think students learn best when it comes to the area of mathematics?
4. What are your thoughts about students' abilities to learn mathematics?
5. What do you consider the best methods for teaching mathematics?
6. How important is it for students to be able to represent mathematical problems in various ways? Why?
7. How important is students' reasoning versus students' correct answers with regard to problem solving in mathematics? Please explain your response.
8. Do you feel all mathematical concepts can relate to real-life situations? Why or Why not?
9. What do you believe prevents students from mathematical understanding?
10. What are your thoughts about your own experience with learning mathematics during your K-12 education?
11. How well do you feel your K-12 mathematics education experience prepared you?
12. How confident do you feel about your understanding of the concepts behind mathematical principles? Please explain your response.
13. How well do you feel the teacher education program is preparing you for teaching mathematics in the future?

14. Do you have any other thoughts about your own mathematics learning and the current trends in K-12 mathematics teaching or teacher preparation?

APPENDIX C

HUMAN SUBJECTS APPROVAL

SIU Southern Illinois University
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HSC Approval letter (exempt)

To: Angel Marjanovich

From: Wayne R. Glass, CRA
Interim Chair, Human Subjects Committee

Date: November 23, 2015

Subject: *Pre-service Teachers' Perceptions of Their K-12 Mathematics Education Experiences and Their Future Mathematics Teaching Practices*

Protocol Number: 15399

The revisions to the above referenced study have been approved by the SIUC Human Subjects Committee. The study is determined to be exempt according to 45 CFR 46.101(b)2. This approval does not have an expiration date; however, any future modifications to your protocol must be submitted to the Committee for review and approval prior to their implementation.

Your Form A approval is enclosed.

This institution has an Assurance on file with the USDHHS Office of Human Research Protection. The Assurance number is FWA00005334.

WG:kr

Cc: Lingguo Bu

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- University Honors Program, 1998
- Academic Scholarship, 1997
- Phi Theta Kappa Honor Society, 1996
- Merit Recognition Scholarship, 1995

Thesis Title:

Pre-service Teachers' Perceptions of Their K-12 Mathematics Education Experiences and Their Future Mathematics Teaching Practices

Major Professor: Dr. Lingguo Bu