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Student Perceptions of the Defining Aspects of a Mathematics Methods Course that Aided in the Development of a Conceptual Understanding of Mathematics

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STUDENT PERCEPTIONS OF THE DEFINING ASPECTS OF A MATHEMATICS METHODS COURSE THAT AIDED IN THE DEVELOPMENT OF A CONCEPTUAL UNDERSTANDING OF MATHEMATICS

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Dedicated to Jill Kennedy, a women of great fortitude
and generosity, without whose encouragement
this journey would have never begun.

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ABSTRACT

The purpose of this study was to ascertain pre-service teachers' perceptions of the defining aspects of a mathematics methods course that aided in the development of a conceptual understanding of mathematics. These perceptions emerge from the narratives of four pre-service teachers in a mid-size metropolitan university in the southeastern part of the United States. Grounded in the theory of constructivism this study focuses on the educational experiences of pre-service teachers, as reported by pre-service teachers, creating a portrait of their journey. These pre-service teachers' learning experiences were based on national standards with a constructivist instructional approach and included field experience in a school environment. Analysis of the data revealed that pre-service teachers attributed their increase in conceptual understanding of mathematics to 'touching/doing activities' that required them to 'explain why'. Use of models and manipulatives aided in helping the pre-service teachers verify and justify their solutions to others, providing concrete items to use in explaining abstract concepts. Ultimately, requiring pre-service to explain their own thought processes, with and without manipulatives, aided them in developing a conceptual understanding of mathematics.

CHAPTER ONE
STUDY OVERVIEW

I touch the future I teach

Christa McAuliffe

Introduction

Invariably whenever I am at a social gathering, someone will ask me what I do for a living. I continue to be amazed at the usual reaction I receive when I state, “I teach math.” The facial expression is the first thing I notice. A flash of fear races across their eyes and then an apologetic statement of “I was never good at math,” as if somehow they must confess to me a fear or dislike of mathematics. Often people are impressed by my ability to understand mathematics as if I possess some knowledge uncommon to the masses. What is it about mathematics that inspires in so many people a feeling of failure, an inability to understand mathematics? Even more astounding is that many of these individuals are elementary school teachers! Could it be that most people, including teachers, do not perceive mathematics as logical or useful in everyday life? If this is true, what can I do to change this supposition?

The National Council of Teachers of Mathematics (NCTM, 2000) has been a major proponent of developing teaching strategies that aid in the understanding of mathematical concepts. The standards as proposed by NCTM, influenced by the constructivist approach, emphasize teaching for a 'deep' understanding of mathematical concepts. In addition, the standards attempt to describe what mathematics children at various ages should know and be able to do and maintain a focus on solving problems that originate in real world situations. Attainment of such goals requires that those doing the teaching of mathematical concepts must understand those concepts they are teaching.

While the ideal first year elementary mathematics teacher would be one who possesses great mathematical knowledge and understanding and can pass this understanding onto others, the reality is far different. We can find in schools today many teachers trying to present concepts to students that they themselves do not completely understand. Ma, (1999) noted "even expert teachers, experienced teachers who were mathematically confident, and teachers who actively participated in current mathematics teaching reform did not seem to have a thorough knowledge of the mathematics taught in elementary school" (p. xix). These teachers may be able to solve a mathematics problem and get the correct solution but the 'sense' of the problem is still evasive.

Why does this occur? One of the reasons is that many pre-service teachers are fearful of mathematics. "There is the great fear of incorrectly solving the problem and looking foolish. Students do not want anyone to know how 'stupid' they are. They feel totally lost and assume everyone knows more than they do"

(Nirenberg, 1997, p. 6). Yet, what can an instructor of a mathematics methods course do to prepare these teachers more appropriately, despite these fears?

"Serious mathematical thinking takes time as well as intellectual courage. A learning environment that supports problem solving must allow students time to puzzle, to be stuck, to try alternatives and to confer with one another" (NCTM, 1999, p. 25). Therefore, in order to develop an understanding of mathematics concepts fully, one must spend time exploring and investigating (NCTM 2000; Van de Walle, 2003; Nirenberg, 1997; Brooks & Brooks, 1993).

Given the time constraints of teacher education, fully exploring all elementary mathematics concepts is not possible. Most pre-service elementary teachers are given two semesters of minimal level mathematics and a one-semester mathematics methods course and are then expected to teach it in depth once they graduate.

Due to this limited exposure to mathematics methods, and the great amount of concepts to be addressed in the course, most pre-service elementary teachers receive little, if any, methods devoted to developing mathematical concepts in depth. Ball (1991) argues that these courses do not provide adequate time to develop or focus on the substantive mathematical knowledge needed to prepare elementary teachers adequately for teaching mathematical concepts. Therefore, much of the understanding of mathematics concepts must be completed on the job and is often met with little success. Without the opportunity during their own instruction to understand mathematical concepts themselves, how will these beginning teachers be able to help their own students to understand the concepts? As Burns (1998) points out "despite the reality that learning math was a bust for so many of us, we have pressed on with ineffective teaching approaches that clearly don't work. If they did, math phobia wouldn't be rampant today" (p. x).

Universities, in order to develop teachers that can comply with NCTM standards, must find a way to help pre-service teachers understand that mathematics makes sense. These pre-service teachers must be exposed to methods, which foster a more in-depth understanding of elementary mathematics concepts. Such beginning teachers will then be able to learn along with their own students, to investigate and to help make sense of mathematics through their own teaching. While not ideal, this would be better than the system we now employ of trying to teach every mathematics algorithm and concept an elementary (K– 8) teacher needs to know in one or two semesters. Designing a curriculum that fosters conceptual understanding may yield pre-service teachers less afraid of mathematics, and mathematics phobia may eventually become extinct.

This formative evaluation study will employ qualitative methods: interviews, review of written assignments and student response journals of four students who have recently completed (within one semester) a mathematics methods course.

The analytic question of this study will be:

What are the student perceptions of the defining aspects of a mathematics methods course that aided in the development of a conceptual understanding of mathematics?

This research will assist university professors, educational supervisors, curriculum planners, and school administrators in their quest to foster teachers who have developed or are willing to develop techniques that can make learning mathematics a logical and enjoyable experience. Through a better understanding of what elements in a mathematics methods course, create an increased understanding of mathematics concepts, educational professionals will be able to define and refine these elements to best serve the needs of pre-service teachers.

Focus of the Study: Teaching for Understanding

Bruner (1960/1977) states "Mastery of fundamental ideas of a field involves not only the grasping of general principles, but the development of an attitude toward learning and inquiry, toward guessing and hunches, toward the possibility of solving problems on one's own" (p.20). This mastery of fundamental ideas and attitudes towards learning should be the focus of mathematics methods courses in pre-service teacher education. Nirenberg (1997) points out that mathematics must be "seen, interpreted and taught with the same passion and wholeness that makes any other human activity clear and alive" (p. 5).

One of the fundamental teachings in education is that learning must begin where the students are. Often pre-service elementary school teachers enter methods courses unsure of the mathematics concepts they will be teaching. My entry point therefore begins with those teachers entering a mathematics methods course. It is important to take into account that persons entering a teacher education program bring with them a multitude of understandings that, in many cases, are invisible to them. McLean (1999) points out “these adults already have lived full lives, and bring with them a lifetime of personal experiences, including a substantial body of personal knowledge about the work of teachers” (p. 59). These experiences vary from student to student. Therefore, a one-semester methods course cannot give all of them the mathematical knowledge necessary to become good teachers. The development of teachers who are willing to learn what they do not yet know is essential. Adopting a constructivist approach to teacher education would “emphasize the continuity of human learning and development across all ages, and have very similar ways of viewing the child as constructor of knowledge and the beginning teacher” (McLean, 1999, p. 65).

This construction of knowledge must also include a conceptual understanding of mathematics. Many adults today, including pre-service teachers, have had little exposure to problem solving skills or critical thinking. (Nirenberg, 1997; Burns,

1998) In their earlier schooling, most were given rules and formulas to memorize and not to look much beyond 'getting the correct answer'. Nirenberg (1997) questions, "how many fertile imaginations have been abandoned to rote instruction?" (p. 15).

Pre-service teachers need exposure to methods that:

- help students make connections among mathematical ideas
- help students make connections between conceptual and procedural knowledge
- encourage students to think through a problem rather than rely on memorized procedures
- involve teaching using a variety of manipulatives
- help students see connections between manipulative, pictorial and abstract representations of concepts
- encourage students to talk with each other about mathematics and allow students to relate to mathematics concepts in their own way (Kloosterman and Gainey, 1993).

Such exposure to these methods will enhance pre-service teachers' conceptual understanding of and their own ability to "do" mathematics (NCTM, 2000). Pre-service teachers must move away from mathematics as they have most likely experienced it as students, guided toward a view of mathematics that is more consistent with the standards (Ball, 1988, 1996).

Both pre-service and beginning teachers need to be seen as inquirers, evolving human beings who are constructing their skill at becoming keen observers of children and their learning processes as well as their mathematical understandings. Through their observations, pre-service and beginning teachers should draw conclusions and then modify their own teaching practices to serve the needs of their students best. Each year teachers should revisit and modify their theories of teaching as a new group of students enters their classroom. Through pre-service teacher education, we can develop teachers who are such learners. Fostering this ability in a teacher develops an empowered thinker who has the intellectual power to create increasingly sophisticated understandings through their own cognitive work (Fosnot, 1989).

Theoretical Framework: Constructivism

Constructivism is a theory of learning and of knowing. “It is an epistemological concept that draws from a variety of fields, including philosophy, psychology and science” (Cooper, Gardner, Lambert, Lambert, Slack, Walker and Zimmerman, 1995, p 1). Considered both a cognitive position and a methodological perspective, its original roots are planted by Plato, Dewey, and Piaget. Constructivism, as it pertains to teaching methodologies, is a theoretical concept concerning the attainment of knowledge. This concept holds that all new knowledge is built upon previous knowledge and that individuals have the innate capability to learn through observations and experiences. Helping students integrate new knowledge is the role of the teacher, not to impart knowledge but to guide students in the students' own pursuit of knowledge.

If we accept the proposition that individuals learn by constructing new understandings of relationships how can teachers who have been taught mathematics through predominantly rote learning expect to guide their own students in the pursuit of knowledge. We must change the way we teach teachers if we are to expect a change in their teaching. Teachers must have experience with and an appreciation for a deep understanding of mathematical concepts before allowing a teacher to teach mathematics to others. This "deep understanding occurs when the presence of new information prompts the emergence or enhancement of cognitive structures that enable us to rethink our prior ideas" (Brooks & Brooks, 1993, p 15). Unless pre-service teachers revisit and rethink their understanding of mathematics they will be unable to visualize the methods needed to help their own students learn mathematics.

The National Council of Teachers of Mathematics (NCTM) has been a major force in fostering deep understanding. It is their contention that "those who understand and can do mathematics will have significantly enhanced opportunities and options for shaping their futures" (NCTM, 2000, p 5). As such, the mathematical standards upon which most elementary and secondary curriculums are currently based require teachers who themselves have developed a deep understanding of mathematical concepts. Hence, it is important for university professors to push continually for an expansion of pre-service teachers' frames of reference.

Universities must develop teachers who are going to establish an investigative environment, to teach children to investigate, and be a willing investigator with the students as well. Unless a teacher is comfortable in his/her own understanding of mathematical concepts, a teacher might quickly reject a student's solution without further investigation of the accuracy of the answer. On the other hand, teachers who are secure in their own understandings of mathematical concepts can use questioning to help students realize where there are discrepancies in thought processes. Consequently, a new generation of students will begin to learn to construct their own knowledge rather than being told what it is they need to know and how to do it.

In focusing on understanding what aspects in a mathematics methods course develop such a deep understanding in pre-service teachers, this study hopes to guide others in creating a learning environment that fosters true facilitators of learning mathematics. Teachers of less ability are more inclined to follow a course of study as dictated by a guide or textbook and maintain the status quo. These teachers, because of feelings of inadequacy, are not likely to teach creatively (Piltz & Sund, 1968). Additionally, pre-service teachers who have been exposed to strategies that foster conceptual understanding and who are confident of their conceptual understandings of mathematics will be more likely to help their own students develop a deep understanding of mathematics.

Need for the Study: Mathematics Reform

Current reforms in mathematics education call for teachers to devote more time and attention to developing students' understanding of mathematics. This call has been a long and persistent one, coming from both commissions (Cockcroft, 1982; Collins, 1988; Howson & Wilson, 1986; Mathematical Sciences Education Board, 1991) and professional organizations (Mathematical Association of America, 1991; National Council of Teachers of Mathematics [NCTM], 1989, 2000) alike. Elementary teachers are no longer expected to transmit knowledge through lectures and examples but to teach for conceptual understanding.

This is a daunting task considering the mathematics instruction most pre-service elementary teachers receive in the United States is more concerned with procedures and follows a lecture format (Battista, 1999; Moanouchehri, 1997; O'Brien 1999). "The lack of attention to substantive mathematics preparation, coupled with the questionable quality or appropriateness of the mathematics courses taken by pre-service elementary teachers, provides little chance of changing teachers' beliefs about mathematics or inspiring them to teach differently from the way they were taught" (Reys & Fennel, 2003, p. 278).

Pre-service teachers continue to associate doing math with following the teacher's rule, and knowing mathematics entails remembering and applying the correct rule and having the answer verified by the teacher (Grouws & Schultz, 1996). This view of mathematics as a memorization of rules and procedures is inconsistent with the vision of the NCTM standards. Consequently, a major overhaul of pre-service teacher education is necessary to ensure conceptual understanding of mathematical ideas.

Yet, there are many challenges to overcome if pre-service teachers are to construct a conceptual understanding of mathematics. One challenge of teacher educators, both at the university level and through in-service programs, is to move teachers away from the type of learning experiences encountered in earlier educational settings and guide them toward a view of mathematics that is more consistent with the standards (Ball, 1988, 1996). In addition, Taylor (2002) points out that many pre-service teachers come with "an image of telling and an image of learning as receiving and practicing" (p. 137) and view teaching thinking as an easy task.

Pre-service teachers need to construct their own conceptual understanding of mathematical concepts. Exposure to the work of Kamii (Kamii, 1985, 1990; Kamii and Dominick, 1998; Kamii and Warrington, 1999), Ball (1988, 1991), and

Cobb (Cobb & Bauserfeld, 1995; Cobb, Perlwitz, & Underwood-Gregg, 1998) and Ma (1999) who advocate a constructivist view of mathematics learning, is important. Pre-service teachers must begin to understand that knowledge of mathematics is not to be poured into students or transmitted, but students construct it by resolving situations the students find problematic. In addition, pre-service teachers need to understand the 'big ideas' of mathematics and be able to represent the mathematics they teach as a coherent and connected curriculum resulting in a "profound understanding of fundamental mathematics" (Ma, 1999).

These reforms however do not call for the abandoning of algorithms and procedures but a lessening of emphasis. Ma's (1999) statement in her book *Knowing and Teaching Elementary Mathematics* exemplifies the call for reform best; "it is important for a teacher to know the standard algorithm as well as alternative versions. It is also important for a teacher to know why a certain method is accepted as the standard one, while the other ways can still play a significant role in the approach to the knowledge underlying the algorithm" (p. 14).

While instruction can be designed to promote deeper understanding of mathematical concepts, "the traditional approach to solving problems in the U.S. classroom is to teach a procedure and then assign students problems on which they are to practice the procedure" (Hiebert, 1999, p. 14). There have been many projects and programs that have attempted to move teachers toward a conceptual understanding of the mathematics they will be teaching (Grouws & Schultz, 1996; Robinson, Robinson, & Maceli, 2000). Cognitively Guided Inquiry (Carpenter, Fennema and Frank, 1996; Carpenter, Fennema, Franke, Levi and Empson, 1999), the Purdue Problem-Centered Mathematics Project (Cobb et al., 1991), and Math Solutions (Burns, 1998) are all examples of programs in which the student becomes the constructor of mathematics knowledge.

It is important for instructors to find ways to help pre-service teachers discern between simply teaching an activity and using that activity to help others understand the underlying mathematics concepts involved. Pre-service teachers need to be aware of their own shortcomings in mathematics, possess a willingness to learn methods that will aid in the understanding of the mathematics concepts they are to teach, and to view themselves as life-long learners. Additionally, pre-service teachers must be comfortable with their ability to present concepts and then continue throughout their careers as teachers to investigate methods that will help them to present mathematical concepts to their students.

This is not only important for pre-service teachers during their formal education, but once they have completed their studies as well. Teachers must "continually reflect on how their teaching affects students' learning, seek appropriate professional development opportunities, and make changes based on the new understanding gained in the process" (Taylor, 2000, p. 138). NCTM (2000) concurs, "by pursuing sources of information, building communities of colleagues, and participating in professional development, teachers can continue to grow as professionals" (p. 373).

The National Council of Teachers of Mathematics Standards (2000) advocates the development of conceptual understanding and the use of essential mathematical processes as well as skill proficiency. In order to create teachers that implement these NCTM Standards universities must teach the methods that will promote a deep understanding of mathematics concepts. “It requires that teachers model the process of constructing knowledge in their disciplines, teach that process to students and give students opportunities to practice and become proficient at it” (Baxter, 1999, p. 9).

Although studies have looked at the various ways mathematics courses have been taught, none explored the aspects of the course that the pre-service teachers felt had aided in their development of conceptual understanding. Additionally, I could find only two (Manouchehri & Enderson, 2003; Timmerman, 2003) that studied the aspects of the mathematics methods course in relation to reform-based mathematics. Neither of these included a component that demonstrated an increase in conceptual understanding while enrolled in a mathematics methods course.

Unlike either of the studies, I will examine the pre-service teachers’ perceptions of those concepts that fostered an increase in conceptual understanding after first demonstrating that an increase in conceptual understanding took place while enrolled in a mathematics methods course. Knowing this information will certainly aid others involved in teacher education to implement similar strategies in their classroom thus bringing the National Council of Teachers of Mathematics vision one-step closer.

Method of Investigation: Student Discourse

The format for this study will be the qualitative paradigm, through a phenomenological approach (Rossman & Rallis, 1998). Qualitative methods are generally supported by a constructivist paradigm that portrays a world in which reality is complex, and ever changing. In addition, qualitative methods place informant viewpoints as essential to the understanding of the meanings given to objects and people encountered in their lived experiences. “The use of language is purposive. Overall, people speak with a specific intention. It may be a story they want to tell, an instruction they want to give or simply to describe something they have seen or felt” (Glasserfeld, 1995, p. 129).

The constructivist view forms the epistemological perspective of this study. This offers views that are not often included in more traditional research accounts, such as attitudes, feelings, and ambiance. According to Lawrence-Lightfoot (1997) “the methodology of portraiture, the aesthetic aspects of production that can contribute to the expressive content include the use of keen descriptors that delineate, like line; dissonant refrains that provide nuance, like shadow; and complex details that evoke the impact of color and intricacy of texture" (p. 29).

A primary way individuals make sense of experience is by casting it in narrative form (Bruner, 1990). As the study proceeds, the 'co-construction' of narrative between researcher and participant will produce emergent 'themes'. Produced, through this co-construction, is a rich and detailed portrait of pre-service teachers in a mathematics methods course. Denzin and Lincoln (1998) define such text as valid if it is "sufficiently grounded, triangulated, based on natural indicators, carefully fitted to a theory (and its concepts), comprehensive in scope, credible in terms of member checks, logical, and truthful in terms of its reflection of the phenomenon in questions" (p. 414).

These four pre-service teachers were chosen in a purposeful sampling (Patton, 1990) from a methods and materials course in the College of Education at a mid-size metropolitan university located in the southeastern part of the United States. Choosing the members of the participating sample purposefully provided for information-rich cases for in-depth analysis. Narrative analyses of emergent themes regarding conceptual understanding will be included within a contextual framework (Lawrence-Lightfoot, 1997) to produce collaborative portraits of the pre-service teacher members of the participating sample.

Limitations of the Study

This study is not generalizable to a larger population since only four pre-service teachers were members of the participating sample. The members of the participating sample were students enrolled in my methods course and chosen based upon the results of the pre/post test of conceptual understanding of mathematics, given as part of the mathematics methods course.

Although the pre/post test, designed by the researcher, was given to all students enrolled in a mathematics methods course only students enrolled in my mathematics course were chosen as members of the participating sample. The researcher taught one mathematics methods course and two other methods courses were taught by university professors. The outcome of the pre and post testing in no way affected the students' grade in the course and successful completion of the course was not a requirement for this study. The information obtained in this study may be useful in understanding the difficulties encountered by pre-service teachers in mathematics methods courses.

Recursive and multiple methods of data collection were used, and clear statements of my positions and biases as a researcher are given. Utilization of consistent documentation of my approaches to gathering, analyzing, and interpreting data is an integral part of this study (Rossman & Rallis, 1998). The accompanied review of literature pertains only to the education of pre-service teachers in the United States.

In addition to my role as a researcher in this study, I currently teach a mathematics methods and materials course for pre-service teachers at a public university in the southern part of the United States. The pre-service teachers in this study were my own, but participation in this study began after completion of the course. There is the potential however, for my lived experiences and biases as a supervisor of student teachers, a mentor teacher and a university instructor to color the collection, analysis, and interpretation of data due to my familiarity with pre-service and first-year teachers. I have made a concerted effort to hear and present an accurate analysis of the data, to hear the individual voices of the members of the participating sample, including the use of member checks and multiple data streams (Rossman & Rallis, 1998). Using various methods of analysis (Figure 1), I have employed various strategies and tools of data collection, looking for the points of convergence among them.

Delimitations of the Study

The researcher created the pre/post test on conceptual understanding of mathematics after an exhaustive search of the literature for such a test yielded no results. The pre/post test as designed by the researcher measures the conceptual understanding of specific elementary mathematics concepts. Examined by a panel of experts, these experts judged the pre/post test to meet the standards of face validity. The panel of experts was composed of two middle school mathematics teachers, a high school mathematics teacher, and two professors of mathematics education. Face validity of the pre/post-test is sufficient for this study, as the use of the pre/post test was limited to choosing members of the participating sample for the study.

A second delimitation is the construction of an authentic interpretation of the portraits of the individuals I am studying. I will be creating portraits of pre-service teachers taken from interviews regarding their experiences both good and bad within a mathematics methods course. As Geertz (1973) reminds us, the researcher's work is inevitably interpretative; it is a search for meaning "through piled-up structures of inference and implication" (p.7). Heard in dialogue are the voices of the researcher and the members of the participating sample. "This self-understanding – which emerges out of the intersubjective experience of relationships – becomes the impetus for deep inquiry and the construction of knowledge" (Lawrence-Lightfoot, 1997. p. 136).

Summary of Chapter One

This study was designed to produce portraits of four pre-service teachers enrolled in a mathematics methods course in a mid-size metropolitan university located in the southeastern part of the United States. Narrative analysis and the methodology of emergent themes are used to amplify the pre-service teachers' voices while the methodology of portraiture provides a contextual framework in which to produce their portraits.

The analytic question of this study will be:

What are the student perceptions of the defining aspects of a mathematics methods course that aided in the development of a conceptual understanding of mathematics?

Organization of Study

This chapter introduced the central focus of this study: the experiences of pre-service elementary teachers in a mathematics methods course, which aided in the development of their own conceptual understanding of mathematics. With the current emphasis on higher order thinking skills and hands-on teaching experiences, pre-service teachers need to be given the opportunity to reflect on their individual needs as they journey to become effective teachers. The basic framework for this study is a qualitative study in creating emic portraits of pre-service teachers based on the emergent themes of co-construction of narratives.

Chapter Two, a review of literature, provides a more detailed framework for this study. This chapter includes in-depth views of the theories of constructivism as it relates to both teaching and learning. Additionally presented is, literature related to the methodological approaches used in this study, a rationale for study through self-reflection and narrative, as well as the most essential studies of difficulties encountered by pre-service teachers in a mathematics course.

Chapter Three presents the methodology for this study. The framework of the phenomenological study is a modified version of the portraiture technique as presented by Lawrence-Lightfoot. Addressed through the analysis of emergent themes is the voice in this study. This results in informational narratives of pre-service teachers' perceived needs in a mathematics methods course. The contextual framework for the presentation of the pre-service teachers' voices is explained in the context of historical, personal, physical and transformative features. Therefore, a more thorough portrait emerges of the pre-service teacher and the aspects of a mathematics methods course that aided in an increase of their conceptual understanding of mathematics.

Presented in Chapter Four are my research findings, including data analysis and the portraits of the members of the participating sample. I begin by offering a general overview of the pre-service teachers' journeys through the mathematics methods course and then give a more detailed and richer perspective in portraits of individual members of the participating sample. These portraits, as well as other data sources, are analyzed and emergent themes are then brought to the forefront. From these emergent themes, I present my research findings of this study.

This study culminates in Chapter Five, which contains the conclusions I drew from the study, as well as some recommendations for further investigation.

Glossary of Terms

aesthetic - concerning the appreciation of beauty or good taste

banking model - theory of learning in which the teacher is the bearer of true knowledge and this knowledge is deposited into the student intact where it remains until needed

cognition - the mental process of knowing, including aspects such as awareness, perception, reasoning, and judgment

cognitive - of, characterized by, involving, or relating to cognition

cognitive assimilation - comes about when a thinking organism fits an experience into a conceptual structure it already possesses

***constructivism* -** is a theoretical concept concerning the attainment of knowledge. This concept holds that all new knowledge, is built upon previous knowledge and that individuals have the innate capability to learn through observations and experiences.

***deep understanding* -** occurs when the presence of new information prompts the emergence or enhancement of cognitive structures that enable us to rethink our prior ideas" (Brooks & Brooks, 1993, p 15).

delimitations of study - those aspects of a study's design over which the researcher has no control

emergent themes - an implicit or recurrent idea that become evident from data and give the data shape and form

emic - related to features or items analyzed with respect to their role as structural units in a system, as in behavioral science or linguistics

ethnographers - people who study the scientific description of specific human cultures

intensity sampling- a choosing of a sample that provides rich information that manifest the phenomenon of interest intensely

general interview guide approach - an approach to obtaining data in which the researcher records the questions or issues to be used during the interviewing process

limitations of a study **-** these are the aspects of a study's design over which the researcher has some control

methodology **-** a body of practices, procedures, and rules used by those who work in a discipline or engage in an inquiry

methodological narratives - the making of meaning from personal experience via a process of reflection in which storytelling is the key element

normative - relating to, or prescribing a norm or standard

objectivism **-** a belief that knowledge exists independently of the observer and is to be ‘discovered’

portraiture - a genre of research that seeks to combine science and art through the structure of a phenomenological lens (Lawrence-Lightfoot)

phenomenology - a disciplined, rigorous effort to understand experience profoundly and authentically" (Pinar, 1995, p. 405).

phenomenological inquiry - an investigation that is aesthetic and pre-hermeneutic, a form of interpretive inquiry that focuses on human perception and experience

pre-hermeneutic - interpretive or explanatory

***purposeful sampling* -** sample under study have been selected because they are the "information-rich"

radical constructivism - a pedagogy that advocates that there is never only one right way to understand a concept, therefore it cannot produce a fixed teaching procedure

***reconstructionists* -** believe that we must first deconstruct (take apart) of our own prior knowledge and attitudes and then reconstruct this knowledge through the use of, observation, reflection and everyday practical experience

***sense of mathematics* -** an understanding of numbers (number quantities) and their relationship with each other

transformative - a marked change, as in appearance or character, usually for the better

CHAPTER TWO
REVIEW OF LITERATURE

We can learn much from the reading of others' ideas.
~Patricia Flad Edmiston

Introduction

Chapter Two is a review of the literature relevant to the frameworks of my dissertation. The first section covers the theoretical framework of my study, constructivism, and its importance in teacher education, as well as, the phenomenological aspects of the study.

The second section explains the methodological framework and the various components of the methodology portraiture. The final section details the rationale/need framework of mathematics reform in teacher education.

Theoretical Framework

Constructivism

Constructivism, as it relates to education, adopts the perspective that students construct a framework of knowledge (Cooper, et al., 1995, p. 17). This framework can and does include the use of the students' multiple intelligences and learning styles. People construct knowledge through assimilation and accommodation of concepts as they journey through various life experiences including those of formal education. The exposure to these new experiences increases the brain's flexibility, "since new pathways provide alternate routes to the same destination" (Healy, 1990, p. 52).

Constructivism is distinguishable from other educational theories by the following principles:

- ❖ Knowledge and beliefs are formed within the learner.
- ❖ Learners personally imbue these experiences with meaning.
- ❖ Learning activities should cause learners to gain access to their experiences, knowledge and beliefs.
- ❖ Learning is a social activity that is enhanced by shared inquiry.
- ❖ Reflection and metacognition are essential aspects of constructing knowledge and meaning.
- ❖ Learners play a critical role in assessing their own learning.
- ❖ The outcomes of the learning process are varied and often unpredictable (Cooper, et. al, 1995, p. 17).

This form of constructivism, commonly referred to as social constructivism, challenges the dominant view of knowledge acquisition, called objectivism (Shapiro, 1994, p.3). The objectivist view builds upon the idea that knowledge exists independently of the observer and is to be 'discovered'.

Social constructivists hold the view that each person is to construct his own knowledge, unique to him as an individual yet intricately linked to the knowledge of others, hence socially constructed. Linked to and placed within the individual's own framework of knowledge, new knowledge exists.

Constructivism and Teacher Education

While constructivism can be a guiding philosophy in education, unless someone trains teachers and administrators to be constructivists, this philosophy will never take root. “Basing activities on what children already know and the freedom to experiment with objects is an important part of the constructivistic sociomoral atmosphere because it reflects the teacher’s general attitude toward the child’s interests and ways of knowing. This philosophy includes “recognition of the importance of children’s errors to their construction of knowledge” (DeVries & Zan, 1994, p. 66). This is “perhaps the most distinguishing characteristic of a constructivist approach is the teacher’s respect for children’s error” (DeVries & Zan, 1994, p. 259). Learning to accept children’s errors and to use the error as a learning moment is a skill that must be part of any teacher education program.

It is essential to apply this same constructivist approach when training pre-service teachers to become constructivist in their approach to teaching. An opportunity to address their ambiguities in understanding mathematics and to construct their own knowledge of teaching from their mathematics methods courses is important. Not only must pre-service teachers understand the mathematical concepts they are to teach; they must also develop their own understanding of how to teach effectively these concepts to others.

Polanyi (1969) gives us such an example whereas “a medical student can learn all the symptoms of various diseases, including variations and complications but only clinical practice can enable him to integrate the clues observed on an individual patient to form a correct diagnosis of his illness, rather than an erroneous diagnosis which is often more plausible” (p. 126). The opportunity for pre-service teachers to practice their newly developed skill is an important one. Much like a medical student as an intern, the pre-service teacher must teach in a classroom and construct their own theories of learning and teaching from their experience of teaching and learning. It requires that instructors of pre-service teachers “model the process of constructing knowledge in their disciplines, teach that process to students and give students opportunities to practice and become proficient at it” (Baxter, 1999, p. 9).

Implementing constructivist approaches in pre-service teacher education is not an easy task for two reasons. First, most pre-service teachers were not themselves educated in a constructivistic setting and still subscribe to the ‘banking model’ theory of learning in which the teacher is the bearer of true knowledge and this knowledge is deposited into the student intact where it remains until needed. These traditional models are often didactic, memory-oriented transmission models (Cannella & Reiff, 1994). This type of knowledge is often shallow and students lack a true understanding of the underlying concepts. Retention of this type of knowledge is short term and usually dissipates immediately upon passing any required testing.

Additionally, changing the pre-service teachers' perception to a more constructivistic model requires a willingness on their part to be cast in the role of guide or facilitator who encourages students to explore, question, and develop their own opinions and conclusions. Getting the 'correct' answer is no longer the goal, rather it is the development of the ability to explain why the answer is correct. This not only requires a 'deep understanding' on the part of their students but also by the pre-service and in-service teachers. "Becoming a teacher who helps students to search rather than follow is challenging and, in many ways, frightening" (Brooks & Brooks, 1993, p. 102).

Constructivist teacher education generally falls into two major traditions: developmental or reconstructionist (Canella & Reiff, 1994). Developmental tradition attempts to teach the pre-service teachers to teach in a constructivistic manner. Yet, this is the antithesis to constructivism as it often includes substantial direct instruction in theory and practice with little opportunities for inquiry, discovery, or self-examination. Reconstructionists however, attempt to facilitate pre-service teachers in the deconstruction of their own prior knowledge and attitudes. In addition, they foster an environment that encourages alternate conceptions and premises that may be more serviceable in teaching. In a reconstructionistic program, observation, reflection and everyday practical experience are incorporated.

Conducting teacher education in a setting that promotes investigation and inquiry into the problems of teaching mathematics increases the likelihood of assisting pre-service teachers in becoming inquiring, reflective mathematics teachers (Mewborn, 1999, p. 340). Honebein (1996) gives us seven goals for the design of constructivistic learning environments:

1. Provide experience with the knowledge construction process.
2. Provide experience in and appreciation for multiple perspectives.
3. Embed learning in realistic and relevant contexts.
4. Encourage ownership and voice in the learning process.
5. Embed learning in social experience;
6. Encourage the use of multiple modes of representation.
7. Encourage self-awareness in the knowledge construction process (p. 11).

A reconstructionist learning environment in which the pre-service teachers break down concepts and then recreate their own understanding can aid in developing conceptual understanding. Papert (1990) points out that "better learning will not come from finding better ways for the teacher to instruct but from giving the learner better opportunities to construct" (p. 3). The methods course took place in a constructivistic learning environment. A larger portion of the mathematics methods course was reconstructivistic in nature, however due to time constraints, some components of the methods course also included a developmental approach. This study gives insight into those aspects of a methods course that give the learner, in this case pre-service teachers, an opportunity to construct a conceptual understanding of mathematics.

Phenomenology

Phenomenological research is the careful exploration of complex moments of individual lived experiences, which point beyond the immediacy of the context in which they occurred. Phenomenological researchers therefore attempt to understand the lived experiences of individuals (Polakow, 1984). It requires the researcher to be open- minded and maintain a tolerance for emergent meanings and structures (Rossman & Rallis, 1998).

Analysis in phenomenological research can take the form of a descriptive narrative that presents a collective view of a shared phenomenon (Creswell, 1994). It focuses on “descriptions of how people experience and how they perceive their experience of the phenomena under study” (Glesne, 1999, p. 7). It is through the collaborative effort of both the members of the participating sample and the researcher that this narrative emerges.

Phenomenological research, according to Van Manen (1984) has the following characteristics:

1) It investigates lived experience,
2) It seeks the essence of experiences, what these experiences mean to the individual,
3) It is the conscious practice of thoughtfulness or attunement to the individual,
4) It does not produce knowledge for knowledge's sake; rather it produces knowledge to disclose what it means to be human, and
5) It always embodies a poetic quality.

The phenomena under study will be the lived experiences of pre-service teachers enrolled in a mathematics method course. Through interviews and analysis of their individual portfolio of work, including journal reflections, teacher observations, lesson plans and classroom experiences, a portrait of their journey will emerge. This portrait will aid in understanding what aspects of their mathematics methods course aided in their increased conceptual understanding of mathematics.

Methodological Framework

Portraiture

Portraiture according to Lawrence-Lightfoot and Davis (1997) is a genre of research that seeks to combine science and art through the structure of a phenomenological lens. There are five essential features of portraiture: Context, Voice, Relationship, Emergent Themes, and Aesthetic Whole (Lawrence-Lightfoot & Davis, 1997, p. xvii). *Context* is comprised of three parts: Historical, Personal, and Internal. Context is a rich resource for the researcher's interpretation of the members of the participating samples' thoughts, feelings, and behaviors. *Voice* draws both the researcher and the members of the participating sample into the action. "Voice speaks about stance and perspective, revealing the place from which the portraitist observes and records the action, reflecting her angle of vision, allowing her to perceive patterns and see the strange in the familiar" (Lawrence-Lightfoot & Davis, 1997, p. 105). *Relationships* are ones of reciprocity between the researcher and the participant. It is crucial that the relationship between researcher and participant is one of rapport, if they are to co-construct a narrative that reveals both of their voices and which is later shared by the reader. *Emergent themes* "grow out of data gathering and synthesis, accompanied by generative reflection and interpretive insights" (Lawrence-

Lightfoot & Davis, 1997, p. 188). Finally, the *Aesthetic Whole* where all empirical and literary themes come together in an orderly logical manner, the pieces fall into place allowing us to see the pattern clearly.

Voice

Voice is central in both autobiographical and biographical scholarship. Lawrence-Lightfoot, Davis, Clandinin and Connelly all emphasize the concept of voice. Ayers (1990) has argued that: "What is missing in the research literature is the experience of crisis, is the 'insider's view'. (p. 271). This listening for voice is essential for the co-construction of narrative. This listening for voice entails the researcher playing "a more active listener role in the actor's storytelling" (Lawrence-Lightfoot & Davis, 1997, p. 120). This voice as interpretation, influences and contributes to the shaping of the members of the participating sample' responses. It is essential however; that neither the participant nor the researcher overwhelms the other, thus allowing a co-construction of narrative is to take place.

Participant-researcher relationship plays an important role in the co-construction of narrative. It is through the relationship of portraitist and participant that "access is sought and given, connections made, contracts of reciprocity and responsibility (both formal and informal) developed, trust built, intimacy negotiated, data collected, and knowledge constructed" (Lawrence-Lightfoot & Davis, 1997, p. 135).

Interviewing

Interviewing is a conversation with a purpose (Dexter, 1970). Classification of interviews include the standardized open-ended interview (structured), the informal conversational interview (unstructured), and the general interview guide approach (semi-structured) (Patton, 2002). A standardized open-ended interview requires the careful wording of each question. Before the interview, the researcher defines the problem and formulates the questions ahead of time (Bernard, 1994). The researcher questions the interviewee using the exact questions with the exact wording. The interviewee response is in a normative fashion.

In an informal conversational interview, the format is non-standardized, and the interviewer does not seek normative responses (Lincoln & Guba, 1985, p. 268). This type of unstructured interview is "based on a clear plan that you keep constantly in mind, but are also characterized by a minimum of control over the informant's responses" (Bernard, 1994, p. 209).

The third type is the general interview guide approach. "An interview guide is prepared to ensure that the same basic lines of inquiry are pursued with each person interviewed" (Patton, 2002, p. 343) but unlike the open-ended interview questions do not have to be asked with exact wording. This study employed the general interview guide approach listing questions or issues to address during the interview with the members of the participating sample.

The interview guide approach offers the advantage of ensuring the best use of the limited time available in an interview situation. Additionally, the interview guide makes "interviewing a number of different people more systematic and comprehensive by delimiting in advance the issues to be explored" (Patton, 2002, p. 343).

The conducting of an interview requires certain steps. Although not linear, these steps must take place at some point in the process:

1) Deciding on whom to interview,

2) Preparing for the interview,

3) Initial moves,

4) Pacing the interview and keeping it productive, and

5) Terminating the interview and gaining closure (Lincoln & Guba, 1985).

The researcher “hopes for shifts in perspective, revelations, and new insights” (Lawrence-Lightfoot & Davis, 1997, p. 147). He must “enter the field with a clear intellectual framework and guiding research questions, but fully expects (and welcomes) the adaptation of both her intellectual agenda and her methods to fit the context and the people she is studying" (Lawrence-Lightfoot & Davis, 1997, p. 186).

Emergent Themes

The researcher begins by listening and observing throughout the interview. It is essential that the researcher is open and receptive to all statements, documenting her first impressions, and making note of the familiar and reoccurring themes as well as the deviant opinions and comments. "The development of emergent themes reflects the portraitist's first efforts to bring interpretive insight, analytic scrutiny, and aesthetic order to the collection of data. This is an iterative and generative process" emerging from the data the themes give the data shape and form (Lawrence-Lightfoot & Davis, 1997, p. 185).

Emergent themes grow out of the data collection process and synthesis. Generative reflection, interpretive insights, and analysis accompany it. Miles and Huberman (1994) describe the analytic work of identifying emergent themes, called coding, as the core of the iterative process of qualitative research. It drives ongoing data collection and continual analysis. The researcher's activity is guided by the coding process; a process that must be flexible enough to allow the researcher to change direction as he moves from fieldwork to analysis and back to data collection.

There is however another stage of reflection and retrospective analysis that follows the completion of data collection. Here the researcher sits down and pours through the interview transcripts, observational narratives, field notes, lesson plans, reflections and other written documents in search of unfolding patterns that will present order and clarity to the interpretation of the data. This is the most ambitious and intellectually challenging phase of the research process. (Marshall & Rossmann, 1989, Lawrence-Lightfoot & Davis, 1997).

Miles and Huberman (1994) suggest identifying pattern codes by looking for "recurrent phrases or common threads" (p. 149). According to Lawrence-Lightfoot and Davis, (1997) the "portraitist draws out and constructs emergent themes using five modes of synthesis, convergence, and contrast" (p. 193):

1) We listen for repetitive refrains that are spoken (or appear) frequently and persistently.
2) We listen for resonant metaphors.
3) We listen for the themes expressed through cultural and institutional rituals.
4) We use triangulation to weave together the threads of data converging from a variety of sources.
5) We construct themes and reveal patterns. (Lawrence-Lightfoot & Davis, 1997).

This coding process is a progressive process "of sorting and defining and defining and sorting those scraps of collected data that are applicable to your research purpose" (Glesne, 1999, p. 135).

"The researcher employs various strategies and tools of data collection, looking for the points of convergence among them. Emergent themes arise out of this layering of data, when different lenses frame similar findings" (Lawrence-Lightfoot & Davis, 1997, p. 204). The researcher however must also be concerned with representing the divergent and dissonant views found among the data collected. It is here that "the portraitist attends to the lack of consensus, trying to make sense out of the dissonance, often trying to discern the underlying patterns" (Lawrence-Lightfoot & Davis, 1997, p. 209).

The portraitist therefore must identify the overarching story. "Out of the torrent of data, the flow of perspectives and perceptions from the actors, the portraitist draws the emergent themes and organizes the multifarious threads of individual and collective experience" (Lawrence-Lightfoot & Davis, 1997, p. 247).

Narrative

Connelly and Clandinin (1988) define narrative as "the making of meaning from personal experience via a process of reflection in which storytelling is the key element" (p. 16). Narrative accounts allow the portrayal of the pre-service teachers' work and struggle to achieve meaning and understanding as they journey through their education. These experiences can be reported in various ways "including journal records, interview transcripts, storytelling, class plans (lesson plans) and other writing" (Connelly & Clandinin, 1990, p. 5). This study is unique in that the student is also the teacher and fulfills both roles during their participation in the mathematics methods course.

"Because narrative research aims to tell people's stories and because the purpose of such research is to illustrate how certain, at least reasonably familiar, events can shed light on our work as educators, narrators bear responsibility for portraying others with empathy and consideration" (Fairbanks, 1996, p 321). A distinguishing feature of narrative research is one in which form and content emerge from collaboration and interpretation.

Connelly and Clandinin (1990) note, "in the writing of narrative, it becomes important to sort out whose voice is the dominant one when we write "I" (p. 9) The "I" becomes less distinct in collaborative moments, such as in the co-construction of narrative. Since narrative inquiry moves toward constructing "a caring community" where researchers and members of the participating sample collaborate and contribute to a "shared" perspective, they have the possibility of becoming stories of empowerment (Connelly & Clandinin, 1990).

Mathematics Reform

The National Council of Teachers of Mathematics (NCTM) has been a major force in fostering student understanding of mathematics. It is their contention that "those who understand and can do mathematics will have significantly enhanced opportunities and options for shaping their futures (NCTM, 2000, p. 5). “Recent mathematics education reform in the United States proposes that teachers of mathematics should act as facilitators of learning in the classroom and promote robust mathematical thinking among students" (Manouchehri & Enderson, 2003, p. 113), therefore an essential component of mathematics reform includes fostering teachers who have a conceptual understanding of the mathematics they are to teach.

A review of the literature yielded only two studies that were similar in scope to this study. The first study by Timmerman (2003) is an action research study, qualitative with a quantitative component, in which she presents two cycles of changes she made in an elementary mathematics methods course to reflect reform-based teaching approaches and the results of those changes. The study focuses on changes made in a mathematics methods course due to pre-service teacher input and the resulting effect on exit survey scores. Timmerman (2003) states that she “had to find ways to increase their conceptual understanding of the underlying elementary mathematics topics” yet offers no proof that increased conceptual understanding took place (p. 9). Like many others in the mathematics education field, she was “challenged to find ways to promote a paradigm shift from tradition oriented mathematics teaching toward reform-based teaching and learning” (Timmerman, 2003, p. 9).

Changes that Timmerman (2003) initiated after the first cycle of teaching, Spring 2000, were:

1) Provided an explicit foundation for teaching reform-based mathematics education;
2) Explicitly modeled and conducted a follow-up discussion of the "before-during-after" teaching components of several mathematics lessons. (Van de Walle, 1998);
3) Decreased content from a K – 8 to a pre K – 6 focus.
4) Implemented and evaluated Standards based materials from a variety of sources.
5) Increased analyzing videos of mathematics instruction and use of print cases.

The overall exit scores increased and specific evidence of change or improvement occurred in the areas of 'overall effective instructor', 'overall course worthwhile'. Timmerman (2003) then offers some suggestions for improvement of mathematics education courses:

"(a) using reflective verbal and written communication,

(b) establishing a collaborative mathematical community, and

(c) focusing on a narrower selection of mathematical content" (p. 163).

She then provides details of the suggestions in each category. Timmerman (2003) concludes that action research provided an excellent method to rethink and improve her teaching practices.

Manouchehri and Enderson (2003), in which they studied the impact of using case analysis method on professional growth and development of 50 prospective secondary teachers provides a second example of a study of mathematics methods course content. The study used pre-test and post-test journal entries to determine if professional growth and development had occurred. Questions were not the same for each journal entry but did cover similar themes. The findings of the study indicated that, “the use of case analysis methodology was effective in increasing the participants’ knowledge about problems of practice, in raising their sensitivity toward student learning, and in motivating them to think in greater depth about efficient teaching strategies” (Manouchehri & Enderson, 2003, p. 126). The study did not address conceptual understanding, as its focus was “providing the participants with a lens through which they could view classroom events and interpret them” (p.127).

Numerous studies of teacher knowledge of mathematics however suggest that an insufficient understanding of subject matter exists (Ball, 1988, 1990; Cohen, 1991; Leinhardt & Smith, 1985, Putnam 1992; Simon, 1993). In her book *Knowing and Teaching Mathematics*; Ma (1999) gives specific examples that teachers in the United States lack a profound understanding of fundamental mathematics.

How will instructors of pre-service teachers foster this ‘deep’ or profound understanding of mathematics required by mathematics reform? According to reports such as The Mathematical Education of Teachers (CBMS, 2001), and Knowing and Learning Mathematics for Teaching (National Academy of Sciences, 2001), instructors of elementary mathematics teachers should promote inquiry and should engage their students in problem-based activities that integrate mathematics content and pedagogy. This is important because as Ma (1999) points out, "if a teacher's own knowledge of the mathematics taught in elementary school is limited to procedures, how could we expect his or her classroom to have a tradition of inquiry mathematics?" (p. 153).

Ma (1999) contends that, "teacher education is a strategically critical period during which change can be made" (p. 149). Instructors of pre-service teachers must make a concerted effort to promote a tradition of inquiry and conceptual understanding in their mathematics methods courses. Unfortunately, despite such efforts by instructors to teach by inquiry and for conceptual understanding, studies by Eisenhart, Borko, Underhill, Brown, Jones & Agard, (1992) indicated that, "student teachers tended to interpret the information provided in procedural terms, procedures such as routines for, or lists of, pedagogical strategies” (p. 36). The fostering of teaching for conceptual understanding tended to be misunderstood, or even ignored by the student teachers. It therefore is important for instructors of pre-service teachers to ponder what aspects of a mathematics methods course would aid the likelihood of an increased conceptual understanding of mathematics.

This study attempts to address this concern, by affording pre-service teachers the opportunity to voice the aspects of a mathematics course that aided in an increased understanding of mathematics concepts. Knowledge of these aspects would empower instructors of the methods courses to adapt their own methods of teaching and incorporate those qualities that aid in the conceptual understanding of mathematics.

Summary

In this chapter, I gave an overview of the research related to the various components of the study. I began with the Theoretical Framework whose basis is constructivism. I then investigated the role of constructivism in teacher education and concluded with the research related to phenomenological inquiry. Presentation of the Methodological Framework is next, including research related to interviewing techniques, portraiture, voice, and narrative. I concluded the chapter with an overview of the research related to Mathematics Reform.

CHAPTER THREE
METHODS

Art and science have their meeting point in method.

~ Edward Bulwer-Lytton

Introduction

This is a qualitative study with a quantitative component. It seeks out those aspects of a mathematics methods course that pre-service teachers perceive aided in their increased conceptual understanding of mathematics. The quantitative component, pre/post test scoring, provides evidence that an increase in conceptual understanding took place while these pre-service teachers participated in a mathematics methods course. The major portion of the study, however, is qualitative with in-depth interviews conducted with four pre-service teachers who demonstrated a statistically significant increase in conceptual understanding of mathematics. The in-depth interviews, along with journal reflections, and a portfolio of work completed during the semester, provided for analysis of emergent themes regarding those aspects that aided in an increased conceptual understanding of mathematics.

Site

The target course of this study is a methods and materials course in the College of Education at a mid-size metropolitan university located in the southeastern part of the United States. The university has a student population of 13,000 undergraduate students with 1,365 of these students enrolled in the College of Education. The students in this course are predominantly juniors and seniors who have completed a prerequisite course of study in education and psychology, as well as mathematics content courses. My personal contacts and gatekeepers to these students is the Dean of the College of Education and the Department Head of Teaching and Learning. I negotiated permission from both gatekeepers to contact the students previously enrolled in my mathematics methods and materials course the previous semester for participation in this study.

The members of the participating sample in this study are students that previously enrolled in and completed a mathematics methods course for pre-service teachers for which I was the instructor. The opportunity to use my own students in this study has both positive and negative effects. Positive effects would include my ability to develop rapport with students and an ability to judge more accurately gestures and other physical nuances, due to an almost daily interaction with the members of the participating sample throughout a semester. Negative effects would include my subjectivity regarding those members of the participating sample, the overlapping of my role as researcher and teacher, and concern that my role as a previous teacher may create a hesitancy on the part of the participant to portray a negative view of the course. While backyard research can be extremely valuable, Glesne (1999) cautions, that it requires a heightened consciousness of potential difficulties. Since this is a portrait of a journey, the journey's outcome can and may be different for each individual. I am not judging the merits of my course but simply offering a view of the students' perspective as participants in the course. This research stance helps alleviate the problem of subjectivity as a teacher/researcher as well as decrease the possible hesitancy of students to describe their experiences in this class. Interviews took place after grades were submitted thus alleviating the need to 'please the teacher'. Additionally, I will not be their instructor in any other course while enrolled in their undergraduate program. This is not to say that all their reluctance to give voice to the questions asked was eliminated, just diminished. As a teacher/researcher, I must also be aware that the opposite may occur, where the member of the participating sample will see the interview as an opportunity to enlighten the teacher/researcher on what worked and did not work for the member of the participating sample. This is not necessarily bad but taken into consideration during the analysis of the data. As a researcher, I attempted to be objective and open to comments both good and bad regarding the course and myself as teacher.

I have reflected on these effects both positive and negative and have concluded that the gaining of insight offered by these members of the participating sample in their journeys to becoming teachers outweighs possible negative effects. These portraits offer others the opportunity to see the mathematics methods course from the members of the participating sample standpoint and in doing so aid in discovering what aspects of a mathematics methods course of study aided in their conceptual understanding of mathematics.

Members of the participating sample

The four members of the participating sample for this study, chosen through purposeful sampling, provided information-rich cases for study in-depth. Patton (2002) indicates that, “while one cannot generalize from single cases or very small samples, one can learn from them and learn a great deal” (p. 46). One may employ several different strategies for purposefully selecting information-rich cases; I chose "intensity sampling" as it allowed me to choose specifically those cases that manifest the phenomenon of interest intensely (Patton, 1990). In the case of this study, the members of the participating sample chosen were members of my mathematics methods course that demonstrated a significant increase in conceptual understanding, based upon the results (Table 1) of a pre-test (Appendix A) and post-test (Appendix B) given as part of their course of study.

The pre-test and post-test were comprised of mathematical problems designed to test the conceptual understanding of students. The source of pre-test and post-test items came from two NCTM publications and the textbook used in the mathematics methods course (Table 2). Two middle school mathematics teachers, a high school mathematics teacher, and two professors of mathematics education reviewed the pre-test and post-test problems and concurred that the pre/post test did enable a testing of the conceptual understanding of mathematics.

The pre-test and post-test of conceptual understanding of mathematics were given to all pre-service teachers enrolled in one of the three sections of mathematics methods courses offered by the university. From the three sections, thirty-six pre-service teachers successfully completed both the pre-test and the post-test.

Twenty-two pre-service teachers originally enrolled in my section of the mathematics methods course and completed the pre-test. Three students withdrew from the course during the semester and five students opted not to take the post-test. Listed in Table 1 are the results of the remaining fourteen pre-service teachers, enrolled in the mathematics methods course, who completed the post-test. The pre-service teachers enrolled in my mathematics methods course demonstrated a mean increase of seven points with a standard deviation of fourteen points.

Table 1

Results of Test of Conceptual Understanding in Mathematics for those pre-service teachers enrolled in my mathematics methods course.

Subject	Pre-test Score	Post-test Score	D	D^2
1	62	46	-16	256
5	64	61	-3	9
6	56	62	6	36
7	25	47	22	484
8	56	54	-2	4
10	39	33	-6	36
43	14	22	8	64
51	36	31	-5	25
52*	31	66	35	1225
53*	47	65	18	324
55*	35	53	18	324
56	37	45	8	64
57	44	40	-4	16
58*	39	58	19	361
	X = 41.79	X = 48.79	ΣD = +98	$\Sigma D^2 = 3228$

Note: * indicates member of the participating sample for this study
Participation in the mathematics methods course resulted in an increase (X = 7, SD = 14) in the Conceptual Understanding of Mathematics post-test scores. This increase was statistically significant, t (14) = 1.87, $p < .05$, one-tailed test

Table 2

Source of Pre-Test and Post-Test Items

Test Item #	Pre-Test		Post-Test	
	Source	**Page #**	**Source**	**Page #**
1	PSTM	189	PSTM	189
2	PSTM	152	PSTM	152
3	EMSM	270	EMSM	270
4	EMSM	252	EMSM	252
5	EMSM	275	EMSM	275
6	EMSM	408	EMSM	408
7	EMSM	405	EMSM	405
8	CES	33	CES	33
9	CES	33	CES	33
10	CES	38	CES	38
11	CES	38	CES	38
12	EMSM	256	EMSM	256
13	EMSM	275	EMSM	275
14	EMSM	239	EMSM	239
15	EMSM	219	EMSM	219

Note: All items, except 1, 14, and15, were taken directly from or adapted from the resources as indicated in the chart. For test items 1, 14, and 15 I, based on concepts presented from the indicated source given, created these items.

Key:
CES - Curriculum and Evaluation Standards for School Mathematics: Developing Number Sense; Addenda Series, Grades 5 - 8. NCTM (1991), NCTM Publication, Reston, VA

EMSM - Elementary School Mathematics: Teaching Developmentally, Author: Van de Walle, J. (2003). 5th edition. White Plains, New York: Longman.

PSTM - Professional Standards for Teaching Mathematics, NCTM (2000), NCTM Publication, Reston, VA

Results of the pre-test and post-test indicated that a statistically significant increase in conceptual understanding occurred during the time between pre-test and post-test. From the participants in my mathematics course, I purposefully chose five participants that demonstrated a growth of at least one standard deviation (14 points). I then issued a request for participation in the study verbally and presented to each member of the participating sample a consent form (Appendix C). The five chosen members of the participating sample read and signed the consent form before interviewing took place.

Choosing five members of the participating sample afforded me the protection against the loss of a member of the participating sample due to unforeseen circumstances. Selecting more than five members of the participating sample would generate more data than I would have been able to analyze if I am to provide appropriate attention to details. While five students initially agreed to be members of the participating sample, one member requested withdrawal from the study before interviewing. The four remaining members of the participating sample are the focus of the study.

Components of the Course

The mathematics methods course took place during the fall semester. Twenty-two pre-service teachers participated in class demonstrations, class activities, observations of mentor teachers, and fieldwork consisting of direct teaching experiences. Participants in the mathematics course received a syllabus (Appendix D) on the first day of class containing a description of the course, the requirements of the course and all assignments. Students participated in whole class, small group, partner, and individual assignments throughout the course of the semester.

Instructional Lecture and Activities - During the course of instruction pre-service teachers participated in twenty 1 1/2 - 2 hour classes at the university setting approximately twice weekly. These classes introduced students to the current reforms in mathematics particularly those advocated by the National Council of Teachers of Mathematics (2000), including the use of modeling, manipulatives, contextual problems and teaching for conceptual understanding.

Textbook - Pre-service teachers were required to read van de Walle's, *Elementary and Middles School Mathematics: Teaching Developmentally* and answer questions related to the topics presented during class instruction. This is the standard text for all mathematics methods courses at the university.

Article Reviews - Pre-service teachers had to find and do a brief review of three articles related to the understanding of mathematical concepts.

Field Experience – Assignment of a mentor teacher to paired pre-service teachers allowed for participating in teaching experiences in a classroom setting. The pre-service teachers were required to complete 9 hours of field direct teaching of the mentor teacher's students, in which they implemented activities and teaching methods learned during the course.

Mentor teachers observed the pre-service teachers lessons during their time in the classroom setting. Additionally, mentor teachers offered feedback to the pre-service teachers. This feedback included areas of strength and weaknesses of the pre-service teachers' ability to teach effectively.

Mentor teacher classes consisted of an average of 25 students and all mentor teachers were experienced (> 3 years of teaching) teachers. Grade levels of the mentor teacher's students ranged from 4T (transitional fourth grade) to the sixth grade level. Each pre-service teacher had to individually construct and teach two one-hour long lesson plans, as well as construction of a weeklong unit plan with their partner pre-service teacher. The weeklong unit also required the creation of a formal assessment instrument and rubric.

Observations - Two types of observations were required. These included completion of two *general observations* of classroom procedures, including teaching methods and behavioral components of their mentor teacher's class. Additionally, four *structured observations* of their partner's teaching were required. Each partner observation required the pre-service teacher to observe a particular component of the teaching process.

Teaching Experience Reflections – Following each direct teaching experience participants in the course, were required to complete a self-reflection of the experience.

Video – Videotaping of one of the direct teaching experiences during the weeklong unit was required, as well as a self-evaluation of the video using a provided rubric.

Oral Performance Exam - Each pre-service teacher was required to model three activities. The first required the use of base ten materials to model two-digit subtraction including regrouping of the materials. The second and third activity required the pre-service teacher to use some type of manipulative to model multiplication and division strategies for fractions. I have provided the problems used in the oral presentation exam and the assessment rubric (Appendix E).

Professional Attribute Scale - This is a brief checklist the instructor of the course uses to indicate if the pre-service teacher exemplifies a professional attitude and characteristics of the pre-service teacher. Attributes include punctuality, professional appearance, oral expression, written expression, tact/judgment, dependability, self-initiative, self-confidence, collegiality, interactions with students, and ability to reflect and improve performance.

Two Written Exams - Both exams, comprehensive in nature, consisted of multiple-choice, short answer and essay problems. Completion of the first exam took place at midterm of the semester and the second exam took place near the end of the semester.

Instructor Feedback

Provision of feedback occurred in various manners during the course. Approval of submitted lesson plans occurred after being read, critiqued, and suggestions for improvement, if necessary, given. In some cases, extensive restructuring of the lesson plans were required and lesson plans resubmitted prior to teaching. Following the oral performance, a discussion took place between the pre-service teacher and the instructor providing feedback to students regarding their performance, noting both strengths and areas of improvement.

During the direct teaching experience, the instructor of the methods course observed each pre-service teacher a minimum of two occasions and written feedback given regarding both strengths and areas of improvement in their instruction. Additionally, pre-service teachers received feedback regarding the professionalism exhibited by the pre-service teacher throughout the course.

Constructivist Learning Environment

The general outline of a lesson consisted of brief lectures, followed by demonstrations of various strategies to aid in developing a conceptual understanding of mathematics. These demonstrations encouraged the use of multiple modes of representation of various mathematics concepts. After the demonstrations, participants in the methods course used their newly acquired strategies to solve contextual and/or exploratory problems. Small groups of participants formed to discuss possible solutions thus embedding learning in social experience. The participants in the methods course could choose a demonstrated strategy or one of their own to solve the problems presented in lesson, fostering ownership and voice in the learning process. Whole class discussion in which participants were required to justify their solutions methods completed the lesson.

In order to clarify this component of the course and to ease replication of the study I offer an example (Appendix F) of one of the lessons presented in the mathematics methods course.

Ethical Considerations

Plummer (1983) suggests a combination of broad ethical guidelines with room for personal ethical choice by the researcher. Since I, as a teacher/researcher, have an obligation to protect the rights, values, wishes and needs of the members of the participating sample, I will follow these five basic principals as outlined in Glesne (1999):

(1) Research subjects must have sufficient information to make informed decisions about participating in a study.

(2) Research subjects must be able to withdraw, without penalty, from a study at any point.

(3) All unnecessary risks to a research subject must be eliminated.

(4) Benefits to the subject or society, preferably both, must outweigh all potential risks.

(5) Experiments should be conducted only by qualified investigators (p. 114).

Members of the participating sample interviewed on audiotape, using two tape recorders to ensure taping. Pseudonyms of members of the participating sample ensured anonymity for the members of the participating sample. While videotaped interviews might have been helpful in revisiting any physical nuances, audiotape ensures greater confidentiality on the part of the member of the participating sample. Members of the participating sample may more accurately voice their perceptions due to the increased sense of greater confidentiality afforded by an audiotape of the interview.

In addition, to the above ethical code to guide my behavior I have endeavored to reflect upon ethical considerations throughout the study taking into consideration the continual communication and interaction with research members of the participating sample.

Researcher Stance

The primary methodology for this study will be the science of portraiture. As Lawrence-Lightfoot and Davis (1997) points out "“the aesthetic aspects of production that can contribute to the expressive content include the use of keen descriptors that delineate, like line; dissonant refrains that provide nuance, like shadow; and complex details that evoke the impact of color and the intricacy of texture" (p. 29). I will employ the contextualizing techniques of Lawrence-Lightfoot and Davis (1997) which will provide the framework for my findings.

As a portraitist, I will be listening to the voices of members of the participating sample, co-constructing narratives and searching for emergent themes within those narratives. Geertz (1973) points out, "Small facts are the grist for the social theory mill" (p. 23). As such, these small facts may show that in the particular perception of each pre-service teacher resides a view of what helps and what hinders conceptual understanding of mathematics. Analysis of these emergent themes will foster an overarching view of the aspects in a mathematics methods course that aid in per-service teachers' conceptual understanding.

My portrait however will be one in which I am the lens through which the reader's viewing will take place. It is therefore important for the reader to know who I am, including my inherent biases both good and bad. I therefore present a little of my background in education, mathematics in particular, and of my experiences that may color my own perceptions in finding emergent themes.

I have always loved to learn new things and attempted to 'make sense' of those learned things, this has been especially true with mathematics. Mathematics has always made sense to me and I have always found it fun to find the many different ways in which one could get the 'right answer'. Many of my peers do not share this excitement, including many of those in the educational field.

Although I have attempted to share my ability to 'make sense' of math with my classmates throughout my earlier education, my excitement for sharing what I knew with others often found me in trouble. When solving mathematical problems in elementary school teachers required a problem to be solved only one way, their way. When pressed for a reply 'why' I could not solve a problem a different way, my method was often deemed erroneous despite the fact that I had the same answer as the teacher’s. Later in college, more assured of my understanding of mathematics, it became clear that the reason so many teachers required us to solve problems their way was simply because my teachers did not have an understanding of the concepts they were teaching. They were simply following the procedures of solving a problem as presented in a textbook or had learned it themselves.

Determined not to be this type of teacher I required my students to question ‘why’ an answer was correct and explain ‘why’ their solution works. As a beginning teacher my method of teaching was sometimes questioned by administrators but this soon ended because my students scored sufficiently well on standardized tests and for most administrators, this was all that counted.

Throughout my years of teaching, I have continued to educate myself. After completing my Bachelor of Science degree in Mathematics Education, I earned a Masters degree in Science Teaching, certification in Gifted Instruction and am in the process of completing my doctoral studies in Curriculum and

Instruction. I have attended and continue to attend workshops and seminars whenever possible to keep me abreast of the current trends and technologies in education. My love of learning has not diminished!

I have also tired to pass on to other teachers those aspects of teaching methodologies that I have found beneficial to my own students. I encourage growth and change whenever possible, but I am not willing to pry open the cocoon of those teachers who are trapped in their own procedural way of teaching. I instead concentrate on encouraging growth in those teachers who are open to change.

It is because of this that I now teach pre-service teachers. I want to see that sparkle of understanding at its inception. I want to warn these newcomers to the profession of the pitfalls they may lie in wait and to help them discover their own ways of dealing with them effectively. In facilitating effective teachers, I hope to replenish the diminishing ranks with freshness. It is important to encourage these pre-service teachers to ask why, to challenge the status quo and to seek out alternative ways of reaching out to their own students.

My roles in education have been numerous: classroom teacher grades 7 - 12, mentor teacher, cooperating teacher, math leader at both the school and parish level, supervisor of student teachers, and department chair. All of these experiences will have some influence as I discover the emergent themes in my research.

I have tried my best to be honest with my biases so that the reader of this study understands my perspective as a teacher of future teachers. I do not want or plan to seek out those pre-service teachers that will give accolades to my methods course but to discover what aspects of the methods course helped them to increase their conceptual understanding of mathematics. I want to give these pre-service teachers the opportunity to say what worked and did not work for them, to relate their journey of changing perceptions throughout the course of study. I want to use this knowledge to construct a more effective way of helping pre-service teachers create their own underpinnings of teaching methodology. Overarching everything is my continual desire to learn how to be better at what I do and to discover 'why'.

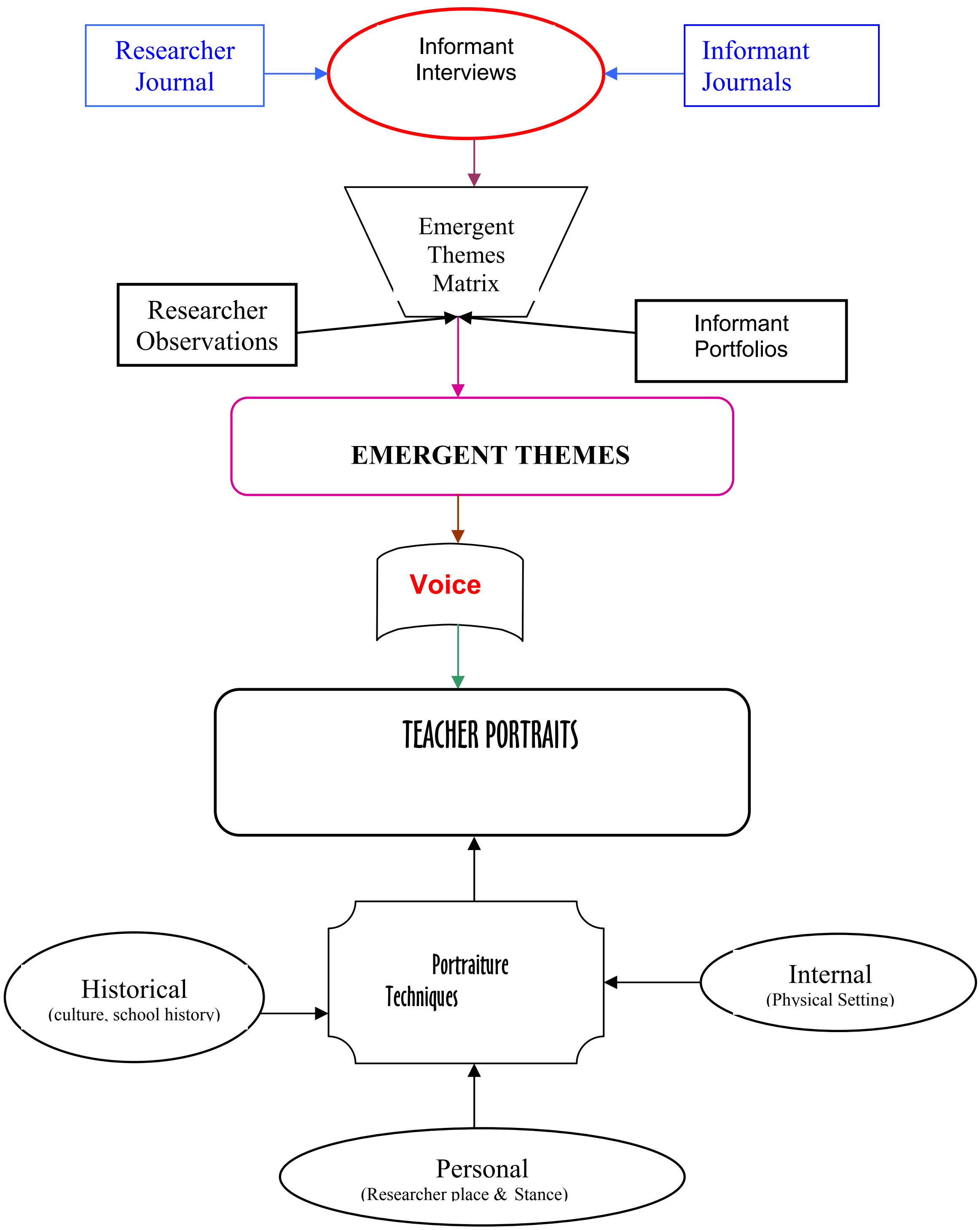
Research Designs

I present a concept map of the research design (inset, Figure 1) to aid in understanding the research design process used in this study. Additionally, I present the details of each of the components of the research design.

Data Collection Strategies

Much like sociological ethnographers, I, as a teacher/researcher, will have developed a close working relationship with the members of the researched group. As such, I must be careful not to impose my own beliefs on the members of the participating sample in the study or to include them in the analysis of the data collected. As a narrative researcher, a number of data collection options are available and I have chosen multiple data sources including oral (interviews) and written (journal reflections and portfolios) data and visual (observations) of the members of the participating sample.

Figure 1. Concept map of research design.



Interviews

Patton states (1980) "the purpose of interviewing, then, is to allow us to enter the other person's perspective" (p. 196). Glesne (1999) suggests that researchers "think of interviewing as the process of getting words to fly" (p. 67). Merriam (1988) believes that interviewing is "the best technique to use when conducting intensive case studies of individuals" (p. 72). Getting words to fly, allowing us to enter another person's perspective and my desire to conduct intensive case studies of individuals all point to my use of interviews as my primary source of data collection. An interview guide (Appendix G) aided the researcher during the interviewing process.

Marshall and Rossman (1989) contend that, "the most important aspect of the interviewer's approach concerns conveying the idea that the participant's information is acceptable and valuable" (p. 82). In narrative research, the interviews should follow the lead of the participant, not the researcher. It is therefore important to word questions carefully because the wording so often determines how the interviewee will respond (Patton, 1990).

I interviewed the four members of the participating sample once two months after the conclusion of the semester long mathematics methods course. As a precaution against instrument malfunction, simultaneous recording of the interview sessions using two cassette recorders was completed. Transcribed verbatim, the transcripts provided the complete narratives of the members of the participating sample for analyses of emergent themes.

Portfolios and Journal Reflections

The members of the participating sample provided the researcher with a portfolio of work including lesson plans, observations, and reflections of both their university-based and field based teaching experiences. Additional reflections submitted via electronic drop box were printed and included in the data analyses. The portfolios and reflections provided additional insight to the pre-service teachers' perspectives and aided in the analyses of emergent themes.

Context

“The portraitist views the context as a dynamic framework – changing and evolving, shaping and being shaped by the actors” (Lawrence-Lightfoot, 1997, p. 59). As such a portraitist I have situated the pre-service teachers’ narratives in a framework of historical (journey, culture, ideology), personal (researcher’s perspective), and internal (physical setting) contexts. Since I am a member of the community I am researching, I will keep a journal of my own changing perspectives throughout the study regarding my observations. This journal will include any insights, perceived changes in members of the participating sample, as well as general observations and insights generated in the field.

Historical

As Lawrence-Lightfoot (1997) suggests, "I will reach beyond the site for input from multiple sources, draw on insights derived from prior research, and keep a watchful eye on the relevance of contextual details to the developing whole" (p. 70). This aspect of the journey is important because it not only needs to set the historical physical site, but the ideological and historical past of the participant.

Personal

The personal context is my own perspectives as teacher/researcher, including my initial reactions and on-going reflections. These perspectives are a part of the narrative, but a part of the periphery, not in the center dominating the action. Most importantly, I have reflected on my own journey during the study and have become more aware about any assumptions or expectations I brought to the research study.

Internal

I have reached beyond the immediate experience of the members of the participating sample to include not only the physical characteristics of their site including geography, demography and the university setting but the social aspects. Descriptions portrayed from macro to micro details help foster a growing understanding of the subject and their physical setting.

Data Analysis Strategies

Data collection and data analysis occurred throughout the seven-week period after the completion of class by the members of the participating sample, thus allowing the researcher to focus and shape the study as it proceeded. Ongoing coding and analysis of data upon receipt helped to organize and manage the information, making the final analysis a much less daunting task. Thick rich description provided the foundation for analysis and reporting of case studies.

Voice: Interviews

Content analysis involves identifying, coding, categorizing, classifying, and labeling the primary patterns in data to determine significance (Patton, 2002). Glesne (1999) points out that "coding is a progressive process of sorting and defining and defining and sorting those scraps of collected data that are applicable to your research purpose" (p. 135). The method of coding, categorizing and theme-searching process as presented by Glesne (1999) aided me in analyzing the data and creating an emergent theme matrix (Appendix H). These emergent themes grew "out of data gathering and synthesis, accompanied by generative reflection and interpretive insights" (Lawrence-Lightfoot, 1999, p. 188). Each interview transcript was read and scrutinized at least four different times giving the researcher the opportunity of listening from different perspectives. After compiling and coding of data individual portraits containing those aspects that aided in the conceptual understanding of mathematics were constructed and shared with members of the participating sample for member checks.

Context

I collected data, including field notes, documents and relevant portions of transcripts, in developing a contextual framework for this study. Analysis of The data collected using a contextual mapping aided in my interpreting the contextual framework that will become an integral part of this study. Context categories for data collection are historical, personal and internal. This contextual framework and the voices of the members of the participating sample are interwoven to create a portrait of those aspects that aided in the members of the participating sample increased conceptual understanding of mathematics.

Trustworthiness

"The four terms "credibility", "transferability", "dependability", and "confirmability" are the naturalist's equivalents for the conventional terms "internal validity", "external validity", "reliability", and "objectivity" (Lincoln & Guba, 1985, p. 300).

Credibility
(Internal Validity)

Patton (2002) suggest that "validity, meaningfulness, and insights generated from qualitative inquiry have more to do with the information richness of the cases selected and the observational/analytical capabilities of the researcher rather than with sample size. Another important criteria, is prolonged engagement as it provides the researcher an opportunity to build trust with the members of the participating sample and occurs when the researcher spends sufficient time at the research site. Persistent observation aids the researcher in identifying those elements that are most characteristic to the phenomena studied. "If prolonged engagement provides scope, persistent observation provides depth" (Lincoln & Guba, 1985, p. 304). The researcher's use of multiple data sources ensures validation of data collected from one source against at least one other source of data.

Prolonged Engagement

Lincoln and Guba (1985) define prolonged engagement as a developmental process to be engaged in daily that ensures: participant anonymity was honored, no hidden agendas existed, interests of the members of the participating sample were honored as much as those of the researcher, and above all, members of the participating sample' confidences were not used against them in any manner. While trust takes a long while to build, it takes only an instant to destroy; therefore, all precautions were taken to ensure that the relationship between the members of the participating sample and the researcher remained one of trust and openness.

Persistent Observation

According to Lincoln and Guba (1985) the "technique of persistent observation adds the dimension of salience to what might otherwise appear to be little more than a mindless immersion" (p. 304). Persistent observation aids in identifying those characteristics and elements throughout the study that are most relevant to the issue pursued and then focuses on them in detail. Eisner (1975) deems these elements "pervasive qualities" or those things that really count. I was careful in sorting out irrelevancies that I was able to recognize and included those atypical aspects that may have importance to the study whenever applicable.

Methods of Analysis

Glesne (1999) states, "the use of multiple data-collection methods contributes to the trustworthiness of the data" (p. 31). A concept map showing the relationship of the three methods of analysis (inset, Figure 2) and outlined below are descriptions of these methods:

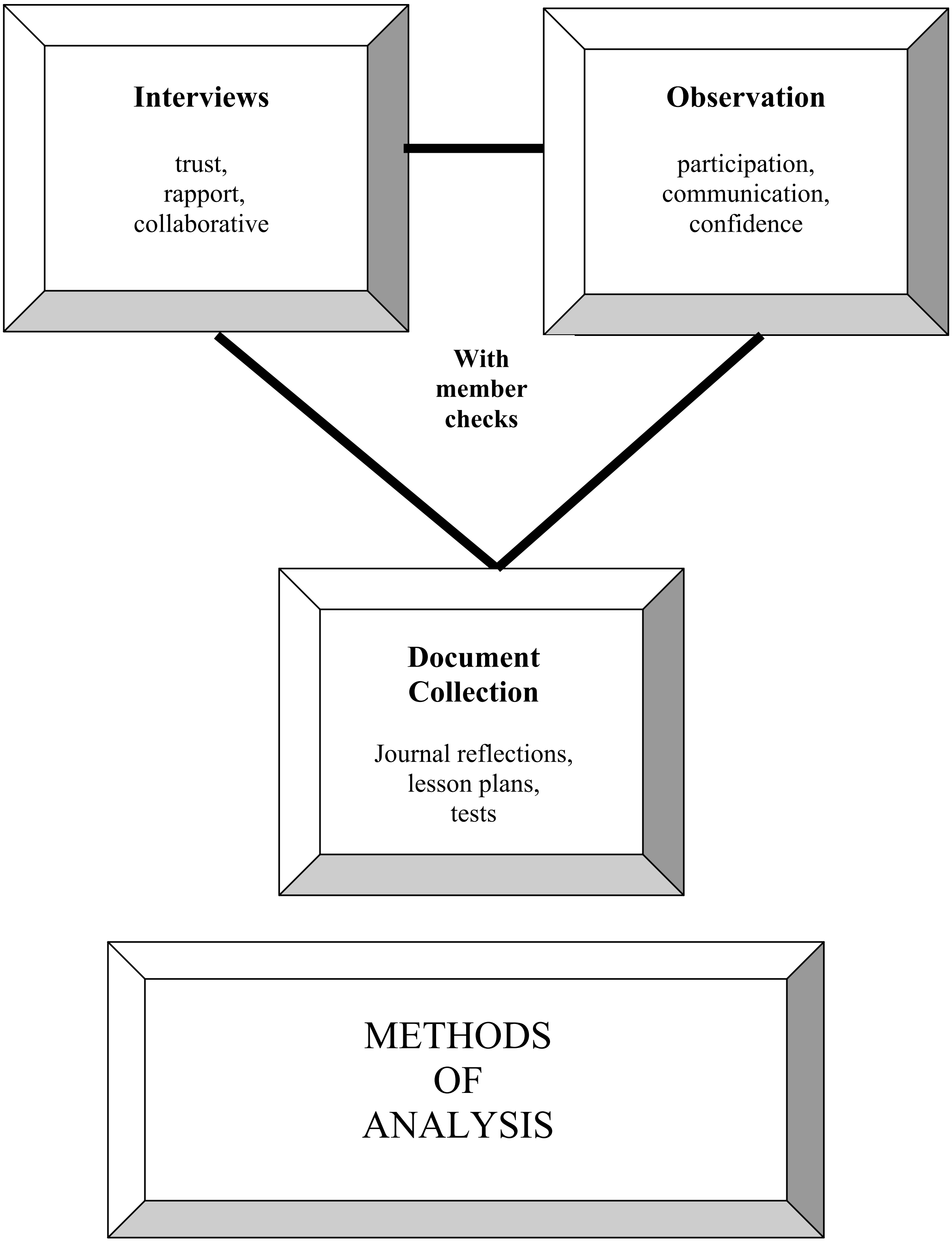
(1) interviews ~ I interviewed the pre-service teachers initially within ten weeks of completing a mathematics methods course. I explored each participant's perception of the changes that occurred regarding their understanding of mathematical concepts and the teaching of these concepts to students. As indicated previously, it is important that I have developed a rapport with and built a relationship of trust with the members of the participating sample throughout the previous semester. The interview was a collaborative one in which participant and researcher constructed a view of their individual journeys of change.

(2) observation ~ I observed members of the participating sample three times in a teaching environment (school setting) and weekly within the context of class participation in the mathematics methods course. A

reflective journal was kept of these dates and times, making notes of any changes I observed in participation, communication with others and displays of confidence in teaching. While data was collected on all participants of the methods course, as part of the regular curriculum of the methods course, only data from the members of the participating sample in this study was analyzed.

(3) document collection ~ Journal reflections by the students regarding their teaching experiences and observations were collected, as well as lesson plans created throughout the semester long course. Test results, including the test, were also collected. In addition, I collected a written reflection from each participant regarding the changes they perceived had occurred in their understanding of mathematics. I have chosen techniques as Glesne (1999) has suggested that “elicit data needed to gain understanding of the phenomenon in question, contribute different perspectives on the issue and make effective use of the time available for data collection” (p. 31).

Figure 2. Concept map of methods of analysis.



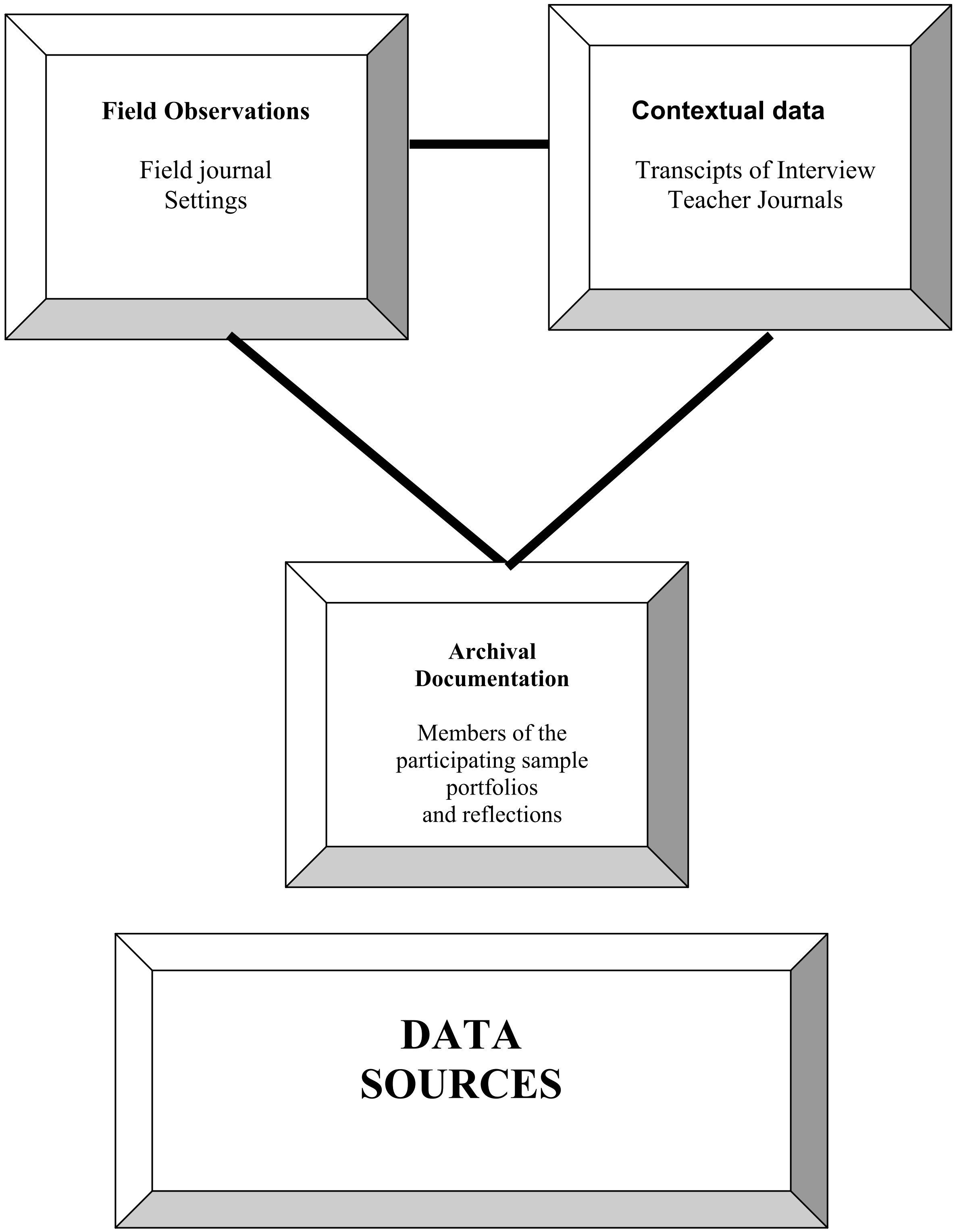
Multiple Data Sources

Patton (2002) points out that "no single method ever adequately solves the problem of rival explanations. Because each method reveals different aspects of empirical reality, multiple methods of data collection and analysis provide more grist for the research mill" (p. 555).

I have chosen to use multiple data sources for, as Patton (2002) points out, in employing multiple data sources "researchers can make substantial strides in overcoming the skepticism that greets singular methods" (p. 556). Multiple data sources will not necessarily yield the same result but used to test for such consistency. Any inconsistencies in results do not weaken the credibility of the results but generate opportunities for deeper insight into the relationship between inquiry approach and the phenomenon under study (Patton, 2002).

Using multiple data sources, (inset, Figure 3) I compared interview results, observations of members of the participating sample, and document collection of journal reflections and portfolios. These three types of data will be brought together to clarify various aspects of a mathematics course that aid in an increased conceptual understanding of mathematics.

Figure 3. Concept map of multiple data sources.



Other Verification Strategies

Member checks by members of the participating sample of emerging themes and patterns are to be incorporated after the construction of emergent theme matrix (Appendix H) and after individual portraits of members of the participating sample have been constructed using the emergent themes. Glesne (1999) points out that the advantage of using member checks with study members of the participating sample may: “(1) verify that you have reflected their perspectives; (2) inform you of sections that, if published, could be problematic for either personal or political reasons; and (3) help you to develop new ideas and interpretations” (p. 152).

I have made every effort to identify and articulate personal biases and interpretation through a written autobiographical disclosure in the format of the researcher’s stance. Disclosure of personal and professional information, which may have affected data collection, analysis, and interpretation, lessens the influence of personal biases and interpretation, although this influence is not eliminated (Patton, 1990).

Outside readers will also be a part of the verification process. These readers, a professor of mathematics education whose research area includes pre-service teachers' conceptual understanding of mathematics and an instructor at the university level, have reviewed the data collected, the emergent theme matrix, and portraits of the members of the participating sample. These outside readers aided in verification of my research findings and conclusions.

Transferability
(External Validity)

Transferability (external validity) as explained by Creswell (1994) pertains to the generalizability of the findings of the study. This study of only five pre-service teachers however is not generalizable to a larger population although it may be of use to others in similar situations. Cresswell (1994) on the other hand, points out that the intent of qualitative studies is not to generalize findings, but to "form a unique interpretation of events" (p. 159).

Transferability, unlike the quantitative researcher's external validity, cannot exist in the form of statistical confidence limits. Instead, the qualitative researcher must provide the thick description "necessary to enable someone interested in making a transfer to reach a conclusion about whether the transfer can be contemplated as a possibility" (Lincoln & Guba, 1985, p. 316). This thick description as defined by Denzin (1988) is "description that goes beyond the mere or bare reporting of an act (thin description), but describes and probes the intentions, motives, meanings, contexts, situations and circumstances of action" (1988, p. 39). As suggested by Guba (1985), in order to facilitate the widest possible range of information for inclusion in the thick description, I will employ purposeful sampling in obtaining my members of the participating sample.

Dependability/Confirmability

(Reliability)

Guba (1985) suggests, using a "stepwise replication, a process that builds on the classic notion of replication in the conventional literature as the means of establishing reliability" (p. 317). Denzin (1998) defines reliability as the extent to which findings can be replicated by another researcher in a reproduced study. The uniqueness of this qualitative study, however, hinders replicating or finding replication in the conventional literature.

To address these concerns Creswell (1994) recommends reporting a detailed protocol of data collection procedures in qualitative studies to facilitate replication. Presentation of a detailed concept map of the research design (Figure 1) for this study, as well as concept maps for methods of analysis (Figure 2) and data sources (Figure 3), may aid in replication of the procedures used in this study. In addition, as suggested by Guba (1981), I will keep a reflective journal noting my role and status within and throughout my participation in the study. This reflective journal will record a variety of information about self, hence reflective, and method. The reflective journal will help keep me aware of any biases that may creep into my collection or analysis of data and the method component can provide information about the methodological decisions made and the reasons for making them.

Summary

The method used in this study is a qualitative approach in which individuals are the primary unit of analysis is the use of portraiture. The portraits, created from interviews, observations, and personal reflections encased in historical, personal, and internal contexts, provided for analysis of emergent themes. These emergent themes woven intricately with themes of constructivism created an aesthetic whole. The use of multiple data sources and multiple methods of analysis, including member checks, added credibility to this study. The result is the description of those aspects of a mathematics methods course that aided in increased conceptual understanding of mathematics.

CHAPTER FOUR
RESEARCH FINDINGS

"Facts" have no meaning except within some value framework, hence, there cannot be an "objective" assessment of any proposition.
~ Guba and Lincoln

Introduction

In this chapter, I take the position that during their participation in a mathematics methods course, the members of the participating sample constructed a conceptual understanding of mathematics through the process of cognitive assimilation. "Cognitive assimilation comes about when a cognizing organism fits an experience into a conceptual structure it already has" (von Glasersfeld, 1995, p. 62). A constructivist learning environment provided the foundation for the development of a conceptual understanding of mathematics.

These members of the participating sample are not a tabla-rasa but entered this mathematics method course with their own set of assumptions about mathematics in general and more specifically of teaching mathematics. Their voice of willingness to explore various methods of teaching tempered their concerns regarding mathematics (V5, p. 3). [Note: V indicates the Volume of from which the data this information is drawn followed by the page number. Volumes 1 – 4 are the transcriptions of the members of the participating sample and volume 5 is a reflection binder kept by me during the course of study. This system is used throughout Chapter Four.]

Integration of what the members of the participating sample learned in the methods course depends on the experiences and cognitive structure of each individual. Radical constructivism holds that there is never only one right way to understand a concept; therefore, it cannot produce a fixed teaching procedure. My goal therefore was to develop a variety of cognitive structures that would aid the course participants in developing a conceptual understanding of mathematics, rather than teaching the participants fixed teaching strategies that would develop a conceptual understanding of mathematics for others. As Kant (1803) pointed out over 200 years ago that, "One trains dogs and horses and one can also train human beings. Training, however, does little; what matters above all is that children learn to think" (p. 450). Gaining exposure to activities that encouraged the course participants to think about their own thought processes may also encourage them to include similar strategies and activities to foster a conceptual understanding of mathematics in the future classes they will teach.

I first present the portraits of the members of the participating sample giving an in-depth view of four of the course participants. I then give an overview of my observations of all of the course participants, including members of the participating sample, as they journeyed through the course.

Portraits

I present portraits of the background and journey of four pre-service teachers, the members of the participating sample, enrolled in my methods course. Interview transcripts, observations, and journals, both my own and the members of the participating sample aided in the development of the portraits. Each member of the participating sample has a pseudonym. Additionally, organization of the portraits consists of a standard format in order to facilitate readability of the portraits.

Five of the course participants who demonstrated a growth of at least one standard deviation (14 points) were invited to be members of the participating sample. Although all five initially agreed, one participant requested withdrawal from the study before interviewing. The portraits are of the four remaining members of the participating sample.

I first present their pre-college experiences in mathematics (background) and then their participation in the methods course (journey) including those components and aspects of the course they felt aided in their increased conceptual understanding.

Amanda ~ The Confident Learner

Background

Amanda had always done well in mathematics. As a member of honors classes throughout her elementary and secondary school years, she did not have a lot of trouble with mathematics. "I was pretty much in an um, gifted and talented classes so we were pretty much removed from the regular education classrooms and left to do this (math) all on our own" (V1, p. 7). Often working in groups with other students, she felt she could internalize what she was doing. The only frustration she encountered in her pre-college mathematics education was the "organization" of written work required by her teachers, one teacher in particular. "I can scribble on three papers to do one problem and so I worked out a deal with her because she was tired of looking for the answer and I was tired of getting counted off points forever. So I would have to draw boxes around the whole problem and circle the exact answer, so that way it was easier for her to see and not get so frustrated with me and I didn't get docked" (V1, p. 10).

Journey

I could see from the very first day of class that Amanda was going to be my ‘student with all the answers’. She was easily frustrated with those who attempted “to simply tune out” because they found mathematics difficult (V5, p. 2). During small group discussion, she was a major force in showing others how to proceed.

"I think I am a very dominating person and I know how to be bold and I know how I want to do it and so sometimes I will be a little overbearing to some people" (V1, p. 2). Although she dominated many of the small group conversations, she always tried to involve the others in her group to discuss the problem and to explain why they thought their answer was the correct one. "Those others who always say well I hated math and never understood it, they, they really probably get it but it's just that they're scared to discuss it because they are so afraid they're going to be wrong. So if you try to explain to them why you do it this way and then ask them to look at it they'll see they're correct" (V1, p. 3).

During both general class discussions and small group discussions, she enjoyed hearing other classmates' opinions on how they solved a problem. Although she would become frustrated with those who would not willingly participate. "To hear other people's opinion on how you can do the problem and their justifying how they got that answer and then myself internalizing the information and then figuring if their way was reasonable and logical" (V1, p. 2). This process allowed Amanda to reconstruct her understanding of a particular concept by viewing it from a different perspective and then assimilating and accommodating it with her own understanding.

Class demonstrations and participation in class activities were sometimes frustrating for her because she already knew how to solve the problems her way and did not want to learn to do it another way. It worked for her; it should work for others. Additionally, at the beginning of the semester she considered the models and manipulatives of minimal importance as she felt everyone should just be able to solve problems with just pencil and paper (V5, p. 5). As the semester progressed, however she began to feel differently. “The fraction rectangles, the Cuisinare rods, they, they helped a lot because I know that fractions are so very hard to understand especially with non common denominators. It helps you to see the relationship between them” (V1, p. 1). The class demonstrations and activities "just gave you another perspective on how it (the concept) could be taught", it "gave a visual about another option about how to teach it or how to view it or how to apply it" (V1, p. 4).

While she did not enjoy creating lesson plans, she understood there was a logical reason for completing one. "We need to know that um, there is a logical reason for doing this before doing this and how they correlate with each other" (V1, p. 5). In addition, creating lesson plans was not difficult for her and she had little sympathy for those classmates that had to put in great time and effort to complete one satisfactorily. "I didn't have a problem, I wrote mine (lesson plans) in like three minutes. Others had put in like five or six hours. I don't understand what they (the other students) were doing" (V. 1, p. 5). The lesson plans however did give Amanda a chance to cognate what she knew regarding a particular concept and her ability to relate it to others. "Just getting it out of my head, written on paper or explaining it to someone else why helped me more because it was just reinforcing what I already knew" (V1, p. 7).

Amanda excelled in her teaching experiences both those in the field at a local elementary school and in the oral presentation completed as part of her midterm examination, but she considered both of these experiences stressful. Amanda found the oral presentation stressful because it required immediate presentation of a concept. "You actually had to sit there and think, step by step what to do, you didn't have it in front of you, you couldn't, that was not something you could memorize because you came in there not knowing the problem" (V1, p. 4). The lesson plans created a different kind of stress for her because she was unprepared for the inability of the fourth-grade students she taught to grasp simple concepts. "Just the basic, even the ruler they didn't know the inches from the centimeters and at this grade you would think they would know that by now" (V1, p. 6). Amanda worked hard to compensate for those skills her students were lacking and to move the students from where they were to developing an understanding of the topic she was teaching.

At the conclusion of the semester, she was even more confident in her ability to teach. Amanda earned high scores in the course and successfully passed on her first attempt of the methods course. When queried as to why she thought her conceptual understanding of mathematics had increased she gave a two-fold response. First, the mathematics methods course gave her a refresher on the concepts she had learned before entering the methods course. Second, the requirement of written expression in completing many of the activities, the explanations and the justification of her answers aided her in gaining a deeper understanding of the concepts she already knew.

Gretchen ~ The Confirming Learner

Background

Math was always one of Gretchen's better subjects but she indicates this has nothing to do with most of the teachers she had in her pre-college school experiences. In high school, she had one good experience. "She (her teacher) would really explain things, made things interesting in Geometry. The rest of the teachers seemed like they would do the long way to do everything. She would show you a couple different ways to do it, she would show you the shortcuts and she would make it interesting. She would discuss things and figure it out a little bit" (V2, p. 1). Along with her friend, who sat next to her in math for the four years of high school, Gretchen explained how to solve various problems to her peers. "The people next to us would ask us, well, how did you do it and when we showed them they would say, that's all you do?" (V2, p. 1).

Journey

Gretchen attempted to reenact this pattern in the methods course by sitting next to Amanda. At the beginning of the semester, it was a challenge to get

Gretchen to be open to various methods of solving problems, partially due to Amanda's ability to show Gretchen 'this is how you do it'. Gretchen began to show more independence as the semester progressed. During small group discussions, she began to show frustration with Amanda's insistence that Gretchen do it her way. Gretchen began to ask more questions of others, including the instructor in the class, and to seek out more information regarding the solving of particular problems. Her continual questioning of why and how different methods worked in solving mathematical problems was evidence of the reconstruction process in developing a conceptual understanding.

Like Amanda, she too enjoyed the discussion aspect of the class both whole class and small group discussion. In referring to whole class discussions, Gretchen was excited about explaining to others how to solve the problems. "You got to hear what other people were saying, and I know a couple of times I actually got up and said why I thought it went a certain way, and that helped me learn the way I was doing it a little better because I would show other people how to do it!" (V2, p. 4).

The models and manipulatives were also an important component of the methods course for Gretchen, especially since this course was Gretchen's first introduction to handling models and manipulatives. "I learned to use more of the manipulatives, I feel like that was the big thing because before, in high school and even in junior high it was all memorization" (V2, p. 3). Additionally, when working with the manipulatives in small groups "we got to discuss it with each other and figure it out on our own how certain things worked" (V2, p. 4). Manipulatives were an important component however, only if, they were used in a small group setting. "When we did it with the whole class we tended to just follow what you were doing because you were doing it with us but when we did it in small groups it was more like having to figure it out on our own" (V2, p. 5).

The creation of lesson plans, as well as the oral presentation, both proved difficult for Gretchen. In both cases, she felt she already knew about the concept she was using, but had difficulty explaining it to others. The oral presentation did help her to explain better in that she had to practice it over and over again and in doing so she began to "understand it a little bit more" (V2, p. 6). The lesson plans also provided a challenge in that she had to take the information regarding a concept and break it down into parts. “A lot of the stuff we were supposed to teach was too difficult for our kids so we had to make it, had to spread it out a lot more, and make it a little easier so they would understand it and do a lot more hands on stuff so they could get the feel of working with it and learning about it” (V2, p. 7).

Gretchen enjoyed her teaching experience in the classroom setting. She realized during her teaching experience that there were sometimes students in her classroom who were experiencing difficulties similar to those she experienced in my methods course. "They (students) might have the whole entire concept by doing it with the manipulatives but when you actually have them do it in writing they don't understand it yet" (V2, p. 8). Unlike the students she taught, Gretchen's problems were in reverse. She had little difficulty in doing problems in writing, but rather in understanding problems conceptually. (V5, p. 6 & p. 14).

Despite her frustration with the students not accomplishing as much as she would have liked them too, Gretchen was successful in her teaching experience. Additionally, the importance of hands on activities in understanding mathematics concepts became evident. Gretchen found that, "The more hands on activities and stuff helped students understand it" (V2, p. 8).

The methods course gave Gretchen an opportunity to confirm those mathematics concepts she already knew how to do. She became more confident in her understanding and felt more comfortable sharing her knowledge with others (V5, p. 23). Gretchen's scores increased as the semester progressed and she successfully passed this first attempt of the mathematics methods course. When asked what suggestions she would give to others teaching a mathematics methods course she stated, "I would tell them to make sure that they let everybody explain why they're doing something. It is very important to be able to explain why" (V2, p. 11).

June ~ The Uncertain Learner

Background

June liked math throughout her elementary school years but had great difficulty with mathematics in high school. "Algebra was really difficult to grasp and I really didn't have any good math teachers which affected me a lot" (V3, p. 1). June had a lot of difficulty keeping up in class but really wanted to understand the concepts. Unfortunately, she felt her teachers were unwilling to help her. “I could see my grade slipping and I'd ask her if she would allow me to meet with her after class for tutoring and she would tell me all the slots were full and made it seem like of all the kids I should have gotten it (the concept)” (V3, p. 1). While her difficulties with mathematics remained resurfaced during college mathematics class, she felt she had become a different person and really wanted to learn. "I think I was a lot more self-motivated person then so it didn't require me to go to them (her teachers) as much. I would kind of go through and teach myself, cause I really wanted to learn" (V3, p. 2). "Sometimes it (the textbook) even had the steps about how you would do it. So I would just figure it out to do it from that" (V3, p. 3).

Journey

June was the most enigmatic of the members of the participating sample, demonstrating both promise and concerns at the beginning of the semester. Early on, she confessed to having difficulties with mathematics but really wanted to understand and to be able to teach it. She was uncertain of her ability in mathematics and it showed, as she was hesitant in voicing the justifications of her answers. More often than not, she was correct in her justifications and over time, she became a bit more confident in her ability to justify her solutions. She particularly enjoyed discussions in class, both whole class and small group. "I always thought that whenever I hear it and whenever I have to explain it to someone else that's when I really get it!" (V3, p. 5). Small group discussion in particular afforded her the opportunity to speak up and to explain how she solved a problem and in doing so developed a better understanding of the concept presented. "It helps me to remember it more whenever I'm telling someone else about it. It forces me to think, of you know, the steps and the concept myself" (V3, p 6). This not only aided in her conceptual understanding but also increased her confidence eroded during her high school experiences in math. "It really boosted my confidence because, you know in my high school experience, I wasn't all that confident in math" (V3, p. 7).

A self-professed auditory learner she, initially, had trouble with the class demonstrations and manipulative use. It was as if she had to "talk" her way through these activities in order to understand what was being demonstrated. June required the inclusion of an explanation of why particular strategies were presented in class. "The teacher is like ya'll are going to do this and this is why. Oh, yeah, that definitely helps!" (V3, p. 9). Once an explanation of why was given the use of the manipulatives made sense. "I could see where they (manipulatives) would help the students. I mean I wish I would have been shown that way as a child but everyone just said this is the way it is" (V3, p. 4).

June, also, had difficulty in developing lesson plans. She was comfortable in her ability to figure out how to solve a math problem but "breaking it down step by step, I found really difficult, you know, because I just wanted them to know how to do it!" (V3, p. 9). June's uncertainty of what was needed in the lesson plan in order to develop the concept was very frustrating for her. "Not knowing what the students knew and not knowing what needed to be added on" she began to realize the importance of knowing how to do the problems herself before presenting the material to the class (V3, p. 9).

This difficulty in not knowing what to be prepared for manifested itself during her first teaching experience. "I didn't realize how much I didn't know until I was up there in front of the class and I realized that they didn't understand what I was saying and I couldn't think of a way of how to relate it to them" (V3, p. 10). Her first teaching experience knocked out much of the confidence she had built up during the semester and it was important for her to succeed in this aspect of the course if she were to become a successful elementary school teacher. "It's really difficult especially with teaching math where there is so many different concepts and you start with the new concept and you realize the class is on a totally different page" (V3, p. 10). As the semester progressed, June worked hard to improve her lesson planning and consequently her teaching experiences improved as well. Her confidence in teaching mathematics continued to increase but a bit of uncertainty regarding her ability to explain the concepts sufficiently was still evident even at the end of the semester. June’s scores in the class remained sufficient to enable her to pass the course successfully on her first attempt of the mathematics methods course.

When asked what suggestions you would offer to a new instructor of this course, she had no hesitancy in stating that more time was needed to observe the students before teaching them. "I would have liked to have more time with the students before I went in to teach them. There's no way especially with a subject as complicated as math to know how to present it to everyone” (V3, p. 12). Additionally, she stated there should be an allocation of more time devoted to developing a good lesson plan, one that focused on aiding her in developing a conceptual understanding of mathematics for others. It is very important to June to be certain she possesses the necessary qualities to teach.

Hailey ~ The Unprepared Learner

Background

Most of Hailey's pre-college experiences in mathematics were classes in which rote memory played a significant role. "I was really good at that memorization thing, things like that" (V4, p. 5). Her teachers would often demonstrate how to solve a problem and she would memorize the steps and duplicate them during testing. The importance of knowing why she was doing the steps never concerned her, so long as she was able to determine the correct answer. Success with memorization has encouraged her to continue to use it even today. "I still find myself cramming for tests, finding that I remember most things when I study for it right before I go in to take an exam" (V4, p. 5). She had limited experience with hands on manipulatives, and those she did encounter were related to geometry such as a ruler for measuring length and a protractor for measuring degrees or in early elementary grades counting items such as buttons. Her participation in mathematics courses was limited to the three courses required by her high school and she had no desire to enroll in additional mathematics courses.

Journey

It was difficult for me to get to know Hailey at the beginning of the semester. She was shy and very hesitant to participate in class. I always felt like I was putting her on the spot when I called on her for a response. She would consistently do her best to participate but had trouble understanding the concepts presented in class. Hailey participated more often in small group discussions. "I'm not very good, um, at communicating with my peers as far as class discussion, I'm still, I work on that but I'm still, I'm not at that point. I've come a long way. I used to be really, really shy. But, um, talking with my partner helped me a lot" (V4, p. 3). After four classes, I concluded that Hailey's lack of participation was not just due to shyness but her lack of a sufficient background in mathematics. She worked hard and took copious amounts of notes, but a basic fundamental understanding of number sense eluded her.

She found the models and manipulatives used in class were helpful but only to a limited degree. She looked upon manipulatives as a way to make the mathematics class fun rather than as a tool to increase conceptual understanding. "I liked, um, one of the create labs, the thing with the circumference with the M & M's and the cookies. That was a lot of fun" (V4, p. 2). "The math games when you were like trying to figure out the answer and you had to see who had the matching card with the answer and they had a problem on the back. That was a lot of fun" (V4, p. 1). While she felt manipulatives helped some people, she felt others wanted specific directions. "I think it mostly depends on the person, some people who are visual it's very helpful for them to be able to see things and others they want step by step they want to do things and they get it out like a process" (V4, p. 2). She particularly liked those class demonstrations in which she could use an algorithm to solve the problem, despite my insistence that solely using standard algorithms was unacceptable. Despite her fondness for algorithms, Hailey found that having to explain how she solved a problem aided in increasing her conceptual understanding. "It actually helped to be able to um, talk about it and you know listen to myself and hear how my thought processes are going" (V4, p. 5).

Hailey approached the creation of lesson plans in much the same manner she approached learning. "I liked having the format, know what each section I was responsible for and having, um, like the rubric that tells me what I'm responsible for in each section. It tells me that I could go back and I could go and make sure that I had everything. I had all my steps, that I had all my professional things and all of that" (V4, p. 6). Having a systematic format made Hailey more comfortable with creating lesson plans, but her lack of understanding the mathematics itself did not enable her to create very effective ones.

Hailey was also very nervous when it came to her teaching experiences, both in the classroom setting and for her oral presentation midterm examination. "It (oral presentation) made me very nervous, but it was good for me. It helped me to work on my verbal skills and communicating, it helped me to realize, well, I want to teach and I have to be able to explain things to anyone not just children so it helps to be able to take what you are thinking and put it into words" (V4, p. 5). She offered no insight to the teaching process itself and did not demonstrate any excitement during teaching. When her lesson did not go as planned, she just kept attempting to teach what she had planned rather than modifying it to the students' needs. "When I was writing my lesson plans because I'd write them and they'd make total sense to me and I'd get out there and I'd think this was easy and the kids just didn't get it. I'd realize that I'm going to have to start thinking about things from more than just my perspective. Which is kind of a hard adjustment to make" (V4, p. 6).

Hailey had made multiple attempts at passing the mathematics methods course, either dropping the course at midterm or receiving non-passing grades. She was also unsuccessful in passing the course this semester. She is planning to pursue a General Studies degree and return to the "elementary teaching program" as an alternate certification student.

Defining Aspects

All four of the members of the participating sample demonstrated an increase in conceptual understanding as shown by the results of the pre/post test (Table 1). Two major aspects of the methods course that aided in this increased conceptual understanding emerged from the portraits of the members of the participating sample, as they tell of their experiences in the mathematics methods course. These two major aspects were 'explaining why' and 'touching/doing activities'.

While there is a relationship between the aspects of this course and the components of this course, they are not one in the same. Through the components of the course, the aspects manifested. I will discuss each aspect individually, citing sources from the interviews, reflections, and observations of the participants, influenced by my own perceptions.

'Explaining Why'

Much of the class requirements involved explaining "why" to others. Discussions, both whole-class and small group, were integral parts of increasing their conceptual understanding. During the discussions in the class students were required to discuss how they solved or could go about solving a problem, explain their thought processes and the if a solution was obtained justify their answer to others. The discussions gave the members of the participating sample an opportunity to think through their own thought processes. "It makes me think, if I have to explain it to someone else it makes me know why and it makes me search for the reason" (V3, p. 6). This type of discussion, the talking about the various problems, was conducive to reflection and as such aided students in 'making sense' of what they were doing. As von Glaserfeld (1995) points out, "In order to describe verbally what we are perceiving, doing, or thinking, we have to distinguish and characterize the items and relations we are using. This often focuses attention on features of our construction that have remained unnoticed, and it is not all uncommon that one of the features, when put into words, leads us to realize that some conclusion we had drawn from the situation is not tenable" (p. 188).

Discussion also allowed these members of the participating sample to hear other perspectives and to internalize those images, accepting or rejecting as the case may be. "I like to hear other people's opinion on how they did it because there are several ways you can do the problem and to hear the other people's opinion on how you can do the problem and their justifying how they got the answer and then myself internalizing and trying to figure it out, if it was reasonable or logical" (V1, p. 2).

Small group (3- 4 students) discussions in particular aided the students in thinking about what they were thinking helping them to reconstruct new understandings of concepts. This meta-cognition was true of Amanda, who was confident in her ability, as well as with June, who was not. Amanda states, "I always tried to, you know, pull it together and tried to explain why you did what you did to the person that was just going along for the ride and wasn't even attempting to try and make a contribution to the group" (V1, p. 1). June, also voices this sentiment, "I would look over at the people that were at the table with me and sometimes they wouldn't get it and I would say 'Oh' and then I would kind of, you know, tell them what I knew" (V3, p. 6).

Offshoots of discussion were the aspects of ‘oral presentations’ and ‘direct teaching experiences’. Both of these cases required the members of the participating sample to explain a particular concept to others. This explaining to others, much like in the previously mentioned discussions, also aided their conceptual understanding.

The oral presentation of the concept of fractions gave the members of the participating sample an opportunity to wrestle with their own understandings, "The thing with the fractions, where you had to multiply the fractions, I never, I never knew you know, how that worked. I knew how to, you know, multiply and everything but I never knew why. So having to explain it and break it down and that helped" (V3, p. 8).

The direct teaching experiences not only afforded the members of the participating sample an opportunity to explain to others, but to explain to others of a different developmental cognitive level (4th - 6th grades). "I'd get out there and I'd think this was easy and the kids just didn't get it" (V4, p. 6). This was quite different then the discussions and explanations among their peers. "I didn't realize how much I didn't know until I was up there in front of the class and I realized that they didn't understand what I was saying and I couldn't think of a way of how to relate it to them" (V3, p. 10).

Touching/Doing Activities

The second aspect of employing 'touching/doing activities', was perceived by the members of the participating sample as increasing a conceptual understanding of mathematics. Examples of touching would be the use of manipulatives and models. These objects aided the members of the participating sample in that it gave a visual and sometimes more concrete representation of abstract concepts. Gretchen pointed out that watching a demonstration by the teacher that used manipulatives was helpful but playing with them and engaging with the manipulatives was even more helpful. Gretchen explains, "Some of the stuff done with the manipulatives helped me remember it a little bit better" (V2, p. 3). June recalls, "It (manipulatives) was helpful because it was like up until college, you know I was never exposed to that many manipulatives. I remember, you know, when it came to fractions they never had anything to show me. So I was like, I wouldn't have known how to take and do it myself if no one would have shown it to me" (V3, p. 8).

Examples of doing activities would be the oral presentation at midterm and the construction of lesson plans, along with field experience during the second half of the semester. These activities required the learner to take apart their initial understandings of mathematical concepts and reconstruct a new understanding that included more detail, resulting in an increased conceptual understanding. In order to explain the concepts to others a more thorough understanding was required. June exemplifies this in her statement, “it makes me think. If I have to explain it (the concept) to someone else it makes me know why and it makes me kind of search for the reason” (V3, p. 6).

Researcher Observations

Throughout the course, I maintained a daily journal for purposes of recording observations of all participants in the course and reflections on the changes in participant behavior and attitudes as the course progressed. An overview of my observations of all participants in the mathematics methods course gives further insight to the development of an increased conceptual understanding of mathematics.

Entry Perspectives

Course participants entered this mathematics methods course with great trepidation, worried about what would be required for this course and whether they would be able to fulfill those requirements. The course participants, however, were cautiously open to learning about new strategies for teaching mathematics. They were very concerned that they did not "really understand" mathematics and therefore felt uncomfortable about teaching it to others. When asked what they expected to learn in this course, the overwhelming response was to be able to understand mathematics enough to feel comfortable teaching it (V5, p.1).

First Reactions

Course participants reacted very positively to their first encounters with learning mathematics conceptually. Comments such as: "Wow, I didn't know that you could do that!" (V5, p. 5), "Why didn't my teachers teach this way? I maybe would have been better at math in high school." (V5, p. 5) and
“That seems so easy, is that all there is to it?” (V5, p. 6). There were however, course participants voiced feelings of being overwhelmed and slightly perplexed with the new concepts presented. Additionally, course participants had initial reservations about the strategies as presented because they preferred the methods by which they had initially learned mathematics in their role as a student. “I learned mathematics the regular way and it was much easier to memorize than do all this stuff we’re doing” (V5, p. 6). “We didn’t have to do all of this, trying to figure stuff out, we just followed the example the teacher showed and we knew we were doing it right. I like knowing we got the answer correctly.” (V5, p. 8).

“New” Ideas

Open to new ideas, the course participants were also open to the new strategies presented in class through demonstrations and activities, and since implementing these strategies into their direct teaching experience was a requirement of the course, all course participants actively began to take part in developing lesson plans that promoted conceptual understanding. These "new" ideas or methods of teaching increased the number of questions the course participants had as they began to clarify their understanding of particular mathematical concepts they were preparing to teach. "I don't want to tell the students the names of the triangles but how do I get this information across without telling them? Is it okay to tell them the names and then classify a whole bunch of different triangles according to the criteria given? Is that how I do it?" (V5, p. 14). "How do I get them to understand that probability looks like a fraction but isn't? It isn't is it? I mean isn't a fraction a number like five where a probability is two numbers put in a fraction?"(V5, p. 15).

As they designed their lesson plans, the course participants were still grappling with fine-tuning their own understanding of the mathematical concepts. Additionally, I found the course participants became very frustrated when I would offer them a myriad of options rather than telling them specifically what to do. The course participants were still stuck in finding the "one right way" even as they were designing lessons that were constructivist in nature.

Self Concerns

Course participants did have some concerns about implementing what they had participated in during class instruction. Although they felt they had a better understanding of the concepts, they still did not feel comfortable with knowing they knew enough to teach it. “I still have to remind myself that I can teach math” (V5, p. 15). These self-concerns regarding teaching diminished as the course participants taught their first lesson and realized that yes, they could teach mathematics and that the students they were teaching were very receptive to learning the concept as well.

The course participants were also concerned that when rushed for time they resorted to teaching the way they were taught as children, back to procedures and memorization. This was particularly true for the course participants who initially had concerns about teaching differently. Although the course participants knew this method of teaching worked, some of the course participants did not like using up so much time. “Teaching this way takes up so much time” (V5, p. 14). “They (the students) get it but it takes so long wouldn’t it be easier just to tell them how to do it?” (V5, p.14). While an increase in the time of direct teaching experience may aid in diminishing this concern as well, I am not sure elimination of these concerns took place even upon completion of the course.

Exit Perspectives

The course participants left the class with the perspective that they had indeed increased their conceptual understanding. An exit survey (Appendix I) showed six course participants agreed their conceptual understanding increased greatly, eleven felt it increased somewhat and three felt it did not have any effect; two did not take the survey.

On the last day of class, I queried the class for some input as to their conceptual understanding and teaching for conceptual understanding. Some of the feedback was as follows:

- "It's like a quote I read somewhere, I never knew what I never knew" "This way was a lot harder to do in the beginning but it gets easier."
- "I wish I would have learned this way, since I now understand fractions better I'm not so afraid to teach it"
- "I really plan to use the manipulatives in my class, it helps to make things make sense, you can see it"
- "I will always remember to ask 'why', cause that's the most important thing" (laugh) (V5, p. 25).

While most of the course participants were more comfortable with teaching through hands-on manipulatives, discussion, and requiring justification of solutions some were just grateful the course was finished. "I'm just glad it's over and I don't have to think so hard anymore " (smile) (V5, p. 25).

Research Findings

The research findings of the course while influenced by the researchers' observations of all course participants centered on the members of the participating sample.

While the members of the participating sample cited components of the mathematics methods course as helpful in increasing their conceptual understanding, it became evident rather quickly that a particular component of the course in and of itself was not the reason for the increased conceptual understanding. Rather the members of the participating sample would cite aspects such as 'explaining why' or hearing others 'explain why' that aided them in developing a conceptual understanding of mathematics. An additional aspect of 'touching/doing activities', including the use of various manipulatives and field experiences, forced them to think about their own thought processes. This meta-cognition process created by completing 'touching/doing activities', also aided the members of the participating sample in the development of a conceptual understanding of mathematics.

As participants in the mathematics methods course, the members of the participating sample had to explain why in many of the components of the mathematics methods course. Course participants, including members of the participating sample, used manipulatives and models to demonstrate their understanding of particular concepts and explain why they solved a problem a particular way. Course participants, including the members of the participating sample, had to reflect on the teaching practices demonstrated to them by the instructor and other participants in the course. They then had to internalize their understanding of the demonstrated teaching practice and accept or reject the explanations given to them by others.

Course participants, including members of the participating sample, were required to explain why certain activities were included or excluded from their lesson plans. They were also required to explain how they would present given concepts to their own students. Class discussion, small group discussion, oral presentation, and field experiences had all course participants, including the members of the participating sample, reflecting on how their thought process worked and then had them explain why they thought their processes made sense, justifying their understanding to others.

Models, manipulatives, and contextual problems such as the 'touching/doing activities' required students to think. These aspects aided in the explanation process by providing the course participants, including members of the participating sample, concrete items to use in explaining abstract concepts.

Student perceptions revealed that the two defining aspects of developing a conceptual understanding of mathematics were 'explaining why' and 'touching/doing activities'. Better learning did not come from demonstrations of fixed teaching procedures but in giving the course participants, including members of the participating sample, better opportunities to construct a conceptual understanding of the mathematics they will be teaching.

Concerns

The analysis of the data was startling and disconcerting simultaneously since the findings of this study reflected my pedagogical basis in teaching mathematics. Startling, for it was not my intention at any point in this study to prove or disprove this pedagogical basis. My goal was to determine which of the components in or aspects of my mathematics methods course aided in the development of a conceptual understanding of mathematics. Others could then incorporate those components and aspects that did aid in the development of a conceptual understanding into their own curriculum. Disconcerting, for it was evident that the none of the components specifically aided in the development of a conceptual understanding of mathematics, rather it was the aspects of 'explaining why' and the 'touching/doing activities' that did so. Therefore, I am concerned that in some unintentional manner I had allowed my role as an educator to over-influence my role as a researcher.

I attempted to ensure credibility by employing multiple data sources and multiple methods of analysis as outlined in Chapter Three. Multiple data sources included field observations of the members of the participating sample, contextual data, and archival documentation. Multiple methods of analysis included: an emergent theme matrix of interviews, analysis of observations and documents related to members of the participating sample, as well as the use of member checks.

Member checks entailed emailing the portraits of the individual members of the participating sample, as well as the findings of my study, to each member of the participating sample respectively as a member check for accuracy in the portrayal of their journey. Three of the four members of the participating sample concurred with my analysis of the data collected and felt their portraits were accurate for the most part and that I had indeed captured their feelings regarding their participation in the methods course, the fourth did not respond to my request for member check. Discrepancies brought to my attention were not related to the findings of the study, but rather to my portrayal of particular attributes of the members of the participating sample such as uncertainty and confidence in participating in the course. Upon reflection of these assertions, I determined that I had done my best to portray accurately each of the participants.

I also compared my observations of the members of the participating sample with the interview transcripts and their reflections of their teaching experiences. I then checked for the consistency of what the members of the participating sample stated about conceptual understanding over time, including both before and after participation in field experiences. Additionally, I requested two colleagues in the Teaching and Learning Department to review the portraits constructed, and the emergent theme matrix and journal data to obtain face validity of my findings.

Patton (2002) points out that “researchers should strive to neither overestimate nor underestimate their effects but to take seriously their responsibility to describe and study what those effects are” (p. 568). I employed both multiple data sources and multiple methods of analysis including member checks and outside reviewers to attempt to ensure credibility. Additionally, I have reflected continuously both throughout the initial contacts with the members of the participating sample and then often during the construction of portraits and analysis of data for biases in the analysis of the data to attempt to remain unbiased in my reporting. The use of these procedures provided assurance that my pedagogy's influence, while it could not be completely eliminated, it did not unfairly influence my data analysis.

Summary

The members of the participating sample indicated in their interviews that they perceived all components of the mathematics methods course, except the textbook, aided in the development of a conceptual understanding of mathematics.

These components however were not the defining aspects but simply devices that required students to reexamine their own thought processes and to assimilate new understandings with previous ones.

Analysis of the data, including interviews, journal reflections, observations, and other documents revealed that an increase in conceptual understanding took place because the components of the mathematics methods course required the members of the participating sample to explain ‘why’ their solutions worked and to be able to justify their solutions to others. This first defining aspect, 'explaining why’ required students to reconstruct their previous understandings of the mathematics concepts presented. Related to and intertwined with the first aspect is the second defining aspect of 'touching/doing activities'. Members of the participating sample often found the use of 'touching/doing activities' helpful in solving mathematics problems and explaining ‘why’ when justifying their solutions to others.

Ultimately, the incorporation into a methods course those 'touching/doing activities' that required reflection of thought processes and justification of solutions through explanations of that thought process are the defining aspects of a mathematics methods course that aids in the development of an increased conceptual understanding of mathematics.

CHAPTER 5
SUMMARY, RECOMMENDATIONS FOR FURTHER RESEARCH AND CONCLUSIONS

We have to remember that what we observe is not nature in itself

but nature exposed to our method of questioning.

~Werner Heisenberg

Introduction

The purpose of this study was to discover what aspects of a mathematics methods course fostered an increase in conceptual understanding of mathematics. Using an interview question guide (Appendix G) I queried students about the relationship between their increased conceptual understanding in mathematics and the components of my mathematics methods course.

Though my study was limited in scope to four participants of the methods course, and as such is not generalizable to all mathematics methods courses, the information contained within may provide insight in developing mathematics methods courses or mathematics workshops for teacher development. Additionally, I have provided recommendations for teachers of mathematics methods courses, teachers of mathematics, both elementary and secondary, and suggestions for further study.

Summary Based on the Research Question

Student perceptions of the defining aspects of a mathematics methods course that aided in the development of a conceptual understanding of mathematics were ‘explaining why’ and ‘touching/doing’ activities. Although members of the participating sample indicated that each of the components of the course, except for the textbook, demonstrated its usefulness in increasing conceptual understanding of mathematics, these components were not the defining aspects. Analysis of the multiple sources of data revealed the components of the mathematics methods course were simply devices that required the members of the participating sample to reexamine their own thought processes and to assimilate new understandings with previous ones providing for an increased conceptual understanding of mathematics.

Observations of the members of the participating sample revealed that at the beginning of the course, three of the members were unsure of their mathematical ability. This is a typical response of students learning mathematics. Nirenberg (1997) points out, "they feel totally lost and assume everyone knows more than they do" (p. 6).

As the course progressed, the members of the participating sample became increasingly confident, with varying degrees, of their conceptual understanding of mathematics. Their willingness to explain to others in the class their thought processes and to justify their solutions to mathematics problems given in class provides evidence of their increasing confidence. The members of the participating sample were becoming inquiring, reflective mathematics teachers, essential aspects of constructing knowledge and meaning (Cooper, et, al, 1995).

Exposure to new experiences such as solving problems through touching/doing activities "increased the brains flexibility, since new pathways provide alternate routes to the same destination" (Healy, 1990, p. 52). It became important for the members of the participating sample to understand "why a certain method is accepted as the standard one" (Ma, 1999, p. 14).

No longer allowed to teach as they were taught, the members of the participating sample were required to create lesson plans that developed a conceptual understanding of mathematical concepts and encouraged to allow their own students to have ownership and voice in the learning process.

However, once the members of the participating sample began teaching experiences within a classroom (field experiences), disillusionment with their newfound conceptual understanding took place for "becoming a teacher who helps students to search rather than follow is challenging and, in many ways, frightening" (Brooks & Brooks, 1993, p. 102). Triggered largely by their inability to implement effectively the strategies learned in class, they were forced again to revisit their earlier understandings. They then were able to refine and to deepen their own conceptual understanding and then to modify their lesson plans, thus enabling the members of the participating sample to break down the mathematical concepts further so that others needing different representation could also begin to understand the mathematical concepts presented.

Not all members of the participating sample were successful in completing the mathematics methods course but all increased their conceptual understanding of mathematics. The members of the participating sample who were successful in completing the course had begun to assimilate the mathematical concepts to the degree where they made tangible efforts, such as lesson plans, to implement the justification of solutions and required explanation of thought processes during their student teaching experience and beyond.

Recommendations

For Mathematics Methods Teachers

Teacher educators must be aware that we cannot train teachers how to teach others but merely offer teachers strategies they can use to aid in developing a conceptual understanding of mathematics in others. This is an impossible task however, unless these pre-service teachers themselves have a conceptual understanding of the mathematics they are to teach to others. Too often in the past, we have sent teachers out into the school environment with generic 'one size fits all' teaching strategies for all subject areas. The teachers then implement these strategies but lose sight of the actual concepts they are teaching. In turn, this fosters a learning environment where individual thought processes are ignored and students are coerced into solving problems the way the teacher shows them, instead of solving the problem conceptually. Increased conceptual understanding of mathematics must be fostered in teacher education programs, as well as in the mathematics curriculum, if teachers are to produce a new generation of learners who conceptually understand mathematics. We must foster teachers who are not afraid of making mistakes or encountering errors. Education needs teachers who are able to justify their understandings of mathematical concepts to both themselves and others. Once this is accomplished, then the cycle will be broken and a new generation of teachers will be ready, willing and able to design learning environments in which all students develop a conceptual understanding of mathematics.

For Mathematics Teachers

This research is not only applicable for teacher educators but perhaps even more so for all teachers of mathematics. While it is imperative for teacher educators to develop teachers who can teach for conceptual understanding of mathematics, it is also important for mathematics teachers at the elementary, secondary and post-secondary levels of education to do the same. Mathematics teachers should note which components contain aspects that are already included in their curriculums that develop conceptual understanding. Especially those that require students to justify their solutions and to explain the students' thought processes when solving mathematical problems. In fostering ownership and voice in the learning process, mathematics teachers will enable students to become contributing members rather than passive observers.

Mathematics teachers should continue to increase their own conceptual understanding of mathematics concepts by discussing their own thought processes with colleagues thus enabling both the teacher and his/her colleagues to increase self-awareness in the knowledge construction process. Finally, by creating learning environments, that require 'explaining why' and 'touching/doing activities', students will in turn increases their own conceptual understanding of mathematics.

For Further Study

Although rich in thick description, this study is of four individuals in a mathematics methods course and is therefore not generalizable to the community at large. Some recommendations I would suggest for further study include:

(1) Investigation of other mathematics methods instructors using the same components of this mathematics methods course. Another teacher using the same components of the methods course might not yield the same results. The instructor's personality may also have had an affect on how the components of the

course were implemented. Another instructor using the same components but not requiring the students to 'explain why' may yield different results.

(2) Investigation of other mathematics methods courses that contain different components of the mathematics methods course than the ones in this study. While the components of this methods course encouraged 'explaining why' and 'touching/doing activities,' can other components be substituted and still achieve the same results? Other components such as daily journals for the students, more time spent in the school environment and multiple resources from outside experts may yield findings quite different from the ones in this study.

(3) Investigation of mathematics teachers at various levels, elementary, secondary, and post-secondary to ascertain if it is the 'explaining why' that aids in developing a conceptual understanding of mathematics in a non-methods mathematics course. Investigating courses at various levels could give insight into what stage of development is appropriate for including justification of solutions and the detail of explanations required. Additionally, if teaching using justification of solutions and explanations shows a development of a conceptual understanding of mathematics at all levels, the findings would be more generalizable to educators in general and to mathematics teachers more directly.

(4) Investigation of age considerations in developing conceptual understanding in mathematics. Since all of the members of the participating sample in this study are less than 30 years old; one may question if the

components that developed a conceptual understanding of mathematics have a lessor affect on older pre-service teachers. Is it possible that the older students are more set in their ways, thus reducing their willingness to participate in conceptual understanding activities?

(5) I would also suggest replication of this study over a number of semesters because it may yield different results regarding the acquisition of a conceptual understanding of mathematics.

Conclusions

"Teacher education is a strategically critical period during which change can be made" (Ma, 1999, p. 149). Therefore, it is imperative that instructors of elementary mathematics teachers create and model a learning environment that promotes inquiry and engages pre-service teachers in problem-based activities that integrate mathematics and pedagogy (CBMS, 2001 & National Academy of Sciences, 2001).

The components of the methods course required the pre-service teachers to spend time exploring and investigating, as suggested by mathematics educators. (NCTM 2000; Van de Walle, 2003; Nirenberg, 1997; Brooks & Brooks, 1993) Additionally, the aspects of the course, 'explaining why' and 'touching/doing activities', fostered self-awareness in the knowledge construction process by requiring all participants to discuss with their peers their thought processes in solving the problems presented. This reflection and metacognition are essential components of developing a conceptual understanding (Cooper, et. al, 1995, Mewborn, 1999). These aspects embedded in the mathematics methods course components succinctly, provided a constructivistic learning environment as described by Honebein (1996).

The concepts presented in problem-based activities and corresponding teaching strategies presented in the course, encouraged ownership and voice in the learning process (Honebein, 1999). Discussion, both whole class and small group, provided an avenue of investigation and inquiry, as suggested by Mewborn (1999) in which the pre-service teachers gained experiences in and appreciation for multiple perspectives (Honebein, 1996). Finally, learning was embedded in social experience providing numerous opportunities for the members of the participating sample to justify and 'explain why'.

The aspects 'explaining why' and 'touching/doing activities' coupled with the pre-service teachers opportunity to practice and become proficient at teaching (Baxter, 1999), break the cycle of ineffective teaching approaches that clearly do not work (Burns, Hiebert, 1999) and replaces them with a constructivist view of mathematics learning and teaching (Ball, 1988, 1991; Kamii, 1985, 1990; Kamii & Dominick, 1998; Kamii and Warrington, 1999; Cobb & Bauserfled, 1995; Cobb, Perlwitz & Underwood-Gregg, 1998; Ma, 1999).

It may not be essential that all the mathematics methods course components are included in a course in order to accomplish development of a conceptual understanding of mathematics. What is important is providing students, whether it be pre-service teachers, members of college mathematics courses, secondary or elementary students, a learning environment that contains 'touching/doing activities' and more importantly requires students to 'explain why'.

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Appendix A

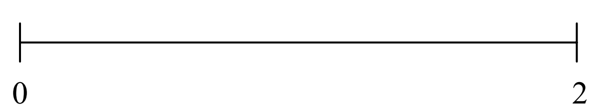
Pre-Test of Mathematics Conceptual Knowledge

1. A rectangle has a perimeter of 8 inches and an area of 4 square inches. The rectangle doubles in size to a perimeter of 16 inches. What is the new rectangle's area measurement? Explain or demonstrate how you found your answer.

2. Without doing a written calculation, will 7 X 18 be smaller or larger than 1000? Explain your reasoning.

3. Michael ate 1/2 of a pizza. Susan came home later and ate 1/4 of the remaining pizza. How much of the original pizza remained uneaten? Explain or demonstrate how you found your answer.

4. Place an X on the number line where 11/8 would be located. Explain why you put your X where you did.



5. Write a real world problem that represents $17 \div 3$.

6. Jennifer states that since her chance of rolling a 5 on one die is 1/6, that her chances or rolling a 7 on two dice is 1/12. Do you agree or disagree with Jennifer and explain your reasoning?

7. Bobby flips a coin 2 times and the coin has landed on heads both of the times. If Bobby flips it a third time is it more likely to land on heads or tails? Explain your reasoning.

8.- 9. Suppose that a, b, and c represent whole numbers different from zero. Suppose also that $a > b > c$. Fill in each box with <, =, or >.

$\frac{a}{b} \square \frac{b}{c}$ $\qquad\qquad$ $\frac{b}{b} \square \frac{b}{c}$

10. - 11. Without performing any calculations, complete each sentence with <, =, or >. Explain your thinking.

$2.23 \times 4.3 \ \square \ 22.3 \times 4.30$ $\qquad\qquad$ $4/5 \times 2/3 \ \square \ 2/3$

12. **Estimate** the answer to 8/15 + 3/7. DO NOT SOLVE but explain your reasoning.

13. Dan paid $2.40 for a 2/3 pound of candy. How much is that per pound? Explain your reasoning.

14. Consider these two computations: 3 ½ X 2 ¼ and 2.14 and 3.12. Without doing the calculations, which do you think is larger? Explain your reasoning.

15. Susan states that 23 X 35 is the same as multiplying 20 X 30 and adding it to 3 X 5. Is she correct? Explain the reasoning for your answer.

Appendix B

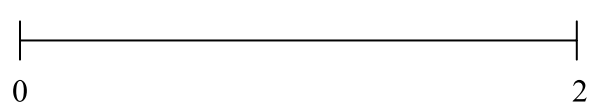
Post-Test of Mathematics Conceptual Knowledge

1. A rectangle has a perimeter of 14 inches and an area of 10 square inches. The rectangle doubles in size to a perimeter of 28 inches. What is the new rectangle's area measurement? Explain or demonstrate how you found your answer.

2. Without doing a written calculation, will 29 X 8 be smaller or larger than 225? Explain your reasoning.

3. Michael ate 1/3 of a pizza. Susan came home later and ate 1/2 of the remaining pizza. How much of the original pizza remained uneaten? Explain or demonstrate how you found your answer.

4. Place an X on the number line where 8/7 would be located. Explain why you put your X where you did.



5. Write a real world problem that represents 15 ÷ 1/2.

6. Jennifer states that since her chance of rolling a 4 on one die is 1/6, that her chances or rolling a 6 on two dice is 1/12. Do you agree or disagree with Jennifer and explain your reasoning?

7. Bobby flips a coin 8 times and the coin has landed on heads 6 of the times. If Bobby flips it a ninth time is it more likely to land on heads or tails? Explain your reasoning.

8.- 9. Suppose that a, b, and c represent whole numbers different from zero. Suppose also that a < b < c. Fill in each box with <, =, or >.

$\frac{a}{b} \; \square \; \frac{b}{c}$ $\qquad$ $\frac{b}{b} \; \square \; \frac{b}{c}$

10. - 11. Without performing any calculations, complete each sentence with <, =, or >. Explain your thinking.

12.5 X 4.8 $\square$ 125 X 4.8 $\qquad$ 1/2 X 7/8 $\square$ 7/8

12. **Estimate** the answer to 12/13 + 7/8. DO NOT SOLVE but explain your reasoning.

13. Dan paid $2.40 for a 3/4 pound of candy. How much is that per pound? Explain your reasoning.

14. Consider these two computations: 3 ½ X 2 ¼ and 2.276 and 3.18. Without doing the calculations, which do you think is larger? Explain your reasoning.

15. Susan states that 25 X 42 is the same as multiplying 20 X 40 and adding it to 5 X 2. Is she correct? Explain the reasoning for your answer.

Appendix C

UNIVERSITY OF NEW ORLEANS

DEPARTMENT OF
CURRICULUM AND INSTRUCTION

CONSENT FORM

1. **Title of Research Study**
   Investigating the mathematical conceptual understandings of pre-service teachers enrolled in a mathematics methods course.

2. **Project Director**
   Patricia F. Edmiston, Doctoral Student, Curriculum and Instruction, University of New Orleans, New Orleans, Louisiana 70148. Job Title: Instructor, Southeastern Louisiana University, Hammond, Louisiana 70402. Telephone: UNO: (504) 280-6607
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This research project is in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Curriculum and Instruction, and under the supervision of Dr. Richard Speaker, Professor, Department of Curriculum and Instruction, University of New Orleans, New Orleans, Louisiana 70148. Telephone: (504) 280-6605

3. **Purpose of the Research Study**
   The purpose of this study is to understand the pre-service teacher's perception of what factors aided in the development of their conceptual understanding of mathematics.

4. **Procedures for the Research Study**
   This research study will consist of the following one individual interview (60 – 90 minutes) and possibly one follow-up interview (30 – 60 minutes) if the need is warranted for further investigation. Participation is entirely voluntary. Both interviews will be audio taped. No video recordings will be involved. By participating in the interviews, you give permission for me to analyze data from your performance in EDUC 321.

CONSENT FORM (Page 2)

5. Potential Risks of Discomforts

There are no known risks associated with the project. Some participants may experience slight emotional distress due to recalling unpleasant experiences or a participant may become tired toward the end of the interview. If you wish to discuss these or any other discomforts you may experience, you may call the Project Director listed in #2 of this form. In addition, if you should have any concerns in this matter call the Project Director or Dr. Scott Bauer, supervising professor at the University of New Orleans. Participation in this study will in no way affect your standing in the Department of Teaching and Learning or assessment in Teacher Education.

6. Potential Benefits to You or Others

While there has been studies giving voice to pre-service teachers' perceptions of participation in a mathematics methods course, none have addressed the student's perception of the factors that aided in their own conceptual understanding of mathematics. The results of this study could be used to assist educators of pre-service teachers in developing a methods course that aides in developing a conceptual understanding of mathematics.

7. Alternative Procedures

There are no alternative procedures. Your participation is entirely voluntary and you may withdraw consent and terminate participation at any time without consequence.

8. Protection of Confidentiality

The names of all participants and their school will be kept confidential at all times. Participants' names or schools will not be identified on the tape or on the transcriptions. Pseudonyms will be employed in both the analysis and summary of data. Although the results of this study my be shared with other doctoral students by peer review, all materials, audio tapes, and consent forms related to this project will be maintained in a secure and confidential manner by the Project Director. If the results of this study are published, participant' names and their schools will be disguised.

9. Signatures and Consent to Participate

Student's Signature and Consent: I have been fully informed of the above described procedure with its possible benefits and risks, and I have given my permission to participate in this study.

I have been fully informed of the above-described procedure with its possible benefits and risks and I have given permission of participation in this study.

______________________	______________________	__________
Signature of Participant	Name of Student Participant	Date
______________________	Patricia F. Edmiston_______	__________
Signature of Project Director	Name of Project Director	Date

Appendix D

Elementary Curriculum & Instruction

Instructor: Ms. Patricia F. Edmiston	Office: TEC 234D
MWF 9:00 – 10:50	Office Hours:
T TH 9:30 – 10:45	Mon: 8 –9; 11-12; 3-4
email:	Tues: 8 – 9; 3 – 4
Phone #:	Wed: 3 – 4 and Fri: 11 - 2

Prerequisites:

Required Textbook (purchase):
Van de Walle, J. (2003). Elementary school mathematics: Teaching developmentally - 5th edition. White Plains, New York: Longman.

Required Supplies:
Each candidate should bring to class everyday the following supplies:
Set of markers (5), scissors, ruler, tape, stapler, basic calculator

Resource Materials:
Many resource materials are available for use in the CREATE lab. Anything published by the National Council of Teachers of Mathematics (NCTM) is likely to be a valuable resource, e.g., Teaching Children Mathematics, Mathematics Teaching in the Middle School. Also very helpful are books by Marilyn Burns Publications.

Course Description:
The content of this block includes the development of teaching competencies in mathematics and reading. Primary emphasis is focused on developing the teaching skills and competencies of future teachers related to these curricular areas while working with individuals and small groups of children in a school environment. The needs of special populations will be considered.

Conceptual Framework Statement of the College of Education & Human Development:
In order to successfully plan, develop and implement curricula to meet the needs of diverse learners in today's world and to prepare candidates for the future, COEHD has identified four critical components of the *Effective Educator:*

- standards-based instruction (SBI)
- best pedagogical practices (PP)
- knowledge of the learner (KL)
- content knowledge (KL)

Course Objectives:

General: The student will be able to:

- understand the roles of elementary teachers and organizational patterns as evidenced by participating in class projects and reading professional literature to show a willingness to become a lifelong learner. (SBI, KL, PP, CK)
- plan developmentally appropriate instruction/lessons in reading and mathematics for children of different cultural backgrounds, ages, and exceptionalities at two different grade levels as evidenced by:

  1) Developing appropriate objectives, which specify designated learning outcomes.
  2) Identifying pupil developmental levels and needs through the use of appropriate assessment/evaluation procedures(i.e. observations, inventories, reflective journals, diagnostic teaching)
  3) Selecting, developing, and adapting appropriate non-stereotyped materials (commercial and teacher –made), resources and technology which match content, objectives, and teaching behaviors as well as meet individual needs of pupils and provide evaluation feedback.
  4) Preparing lesson plans that are based on interests, needs, and developmental levels of pupils and designed to lead toward specific objectives. (SBI, KL, PP, CK)

- Implement the above skillfully as evidenced by:

  1) Presenting accurate, appropriate content in a clear, motivational manner. (CK)
  2) Using effective verbal, non verbal, and written communications. (KL, PP)
  3) Using specific strategies, materials, manipulatives, and visual aids that meet the needs of all students. (SBI, KL, PP)
  4) Using effective questioning techniques at several taxonomic levels to facilitate higher level thinking schools.
  5) Critically solving problems and making decisions as needs and issues arise. (KL, PP)
  6) Integrating math and reading with language arts, science, social studies, and other disciplines. (SBI, PP, CK)

- Organize and manage instruction effectively as evidenced by:

  1) Using various student groupings such as collaborative groups, cooperative learning and peer teaching as appropriate to meet needs, interests and goals. (SBI, KL PP)
  2) Establishing a risk-free environmentally appropriate atmosphere for the physical, social, emotional, and cognitive development of pupils. (SBI, KL, PP, CK)
  3) Using positive classroom management and discipline skills to maintain appropriate student involvement. (SBI, KL, PP)

- Assess teaching and learning appropriately as evidenced by:
  1) Selecting a variety of methods of assessment appropriate to the age, development, and other characteristics of pupils. (SBI, KL, PP, CK)
  2) Interpreting and communicating assessment results to pupils, classroom teachers, etc. (SBI, KL, CK)
  3) Using assessment information to plan further instruction. (SBI, KL, PP, CK)
  4) Critically analyzing all aspects of teaching/learning experience through self and daily lessons and daily reflections. (SBI, KL, PP, CK)

- Observe, respond and interact in an interdisciplinary manner with pears, faculty, support personnel and others involved in public education as evidenced by successful collaborations with all children and adults involved in practicum experience. (KL, PP)

Specific Mathematics Objectives
Upon completion of the course the candidate will be able to:

- A. Create an environment in which students become confident learners and doers of mathematics.
- B. Use a problem solving approach in teaching.
- C. Structure classroom activities so that students learn to relate mathematics to the real world as they:
  1) Solve mathematical problems.
  2) Reason mathematically.
  3) Communicate mathematically through reading, writing, listening and discussing ideas.
  4) Connect mathematical concepts within and to outside domains. (SBI, KL, PP, CK)
- D. Structure classroom activities so that students construct meaningful concepts and skills in:
  1) Numeration and number systems and develop number sense.
  2) The four basic operations and their application.
  3) Computational procedures.
  4) Geometry of one, two and three dimensions.
  5) Mental computations and estimation techniques.
  6) Measurement and related concepts.
  7) Collecting, organizing, representing, analyzing and interpreting data. (SBI, KL, PP, CK)
- E. Use various kinds of calculators and other technologies as teaching tools for computation, problem solving, and exploration. (SBI, KL, PP, CK)
- F. Use manipulative and visual materials to assist students in constructing mathematical concepts. (SBI, KL, PP, CK)
- G. Demonstrate an increased awareness of negative attitudes toward mathematics, math anxieties, and biases in mathematics instruction. (SBI, KL, PP)

- H. Integrate five pervasive themes outlined in the Louisiana Mathematics Content Standards into daily lessons. (SBI, KL, PP, CK)
- I. Use the Louisiana Mathematics Content Standards and Benchmarks as guidelines for lesson planning and instruction. (SBI, KL, PP, CK)
- J. Utilize the Louisiana Components of Effective Teaching as guidelines for lesson planning and instruction. (SBI, PP)
- K. Incorporate state-adopted basal materials and parish guidelines (indicators) as resources for mathematics instruction. (SBI, PP)
- L. Integrate children's literature of various genres to teach mathematical concepts. (SBI, KL, PP, CK)
- M. Embed process- and product-oriented assessment into instruction, including alternative and authentic assessment methods, to monitor student progress and plan developmentally appropriate mathematics instruction. (SBI, KL, PP, CK)
- N. Implement active learning strategies and effective classroom management strategies. (SBI, KL, PP, CK)
- O. Use effective questioning strategies that foster higher-level thinking and problem solving skills. (SBI, KL, PP, CK)
- P. Incorporate technological resources in lesson planning and instruction. (SBI, KL, PP, CK)
- Q. Plan and implement lessons that include instructional strategies, including flexible grouping and planning for multiple intelligences, to accommodate a variety of student differences. (SBI, KL, PP, CK)
- R. Utilize an understanding of the cultural, historical, and scientific applications of mathematics in order to help student learn to value mathematics. (SBI, KL, PP)

Course Evaluation:

- **All** assignments must be completed in order to receive a grade of A or B in the course. **Failure to complete even one requirement will result in a grade of C or lower.**
- All assignments must be completed prior to the beginning of the class period on the due date. Teaching reflections and teaching observations (including peer observations) are due via email by 9:00 am the day following the teaching experience or observation. You will lose 10% of the total possible points or 1 point if the assignment is valued at less than 10 points for each day the assignment is late. **No assignment will be accepted more than two days overdue. (**Note: Over the weekend is considered two days late.)
  If you are absent from class your assignment is still due that day prior to the start of class, simply email me the assignment and then bring a hard copy for evaluation when you return to school.
- Candidates should contact the instructor in advance (prior to the start of class that day) if a test will be missed (you will lose 10% of the total points if the make-up is not cleared in this manner.) IF a make-up test is approved, you will have a maximum of three days from the original date the test was given to make up the test. You will not be given the same test as those who took the test on the

scheduled date. A make-up test will only be given under extreme circumstances and is at the instructor's discretion.

- The candidate should become familiar with the University's policy regarding academic honesty (found in your catalog). A grade of zero points will be received for any assignment or test that is submitted and is not the candidate's own work.
- ALL lesson plans, assessments, article critiques **must be typed (double-spaced, 12 pt font, 1 inch margins) or you will not receive credit.**
- ALL assignments will be evaluated on content and writing mechanics. Three errors will result in a 10% reduction of the grade. Please use complete sentences and proper spelling. Remember neatness counts.
- ALL assignments must include the following in the top left corner. Failure to include the proper heading fully will result in a 1 point loss. No name results in no credit.
  Name and Class #
  Title of Course
  Title of Assignment
  Date
- ALL submissions via email must have your name and the title of the assignment listed in the subject area. I will automatically delete any assignment not submitted in this manner.

Grading Scale (Total possible points: 600)
A = 94 – 100% Superior Performance
B = 87 – 93% Above Average Performance
C = 80 – 86% Average Performance **
D = 70 – 79% Below Average Performance
F = < 70% Failing Performance

** Note: In order to receive credit for this course in the Teaching and Learning Curriculum, a candidate must receive a score of 80% on the University Based Assignments, Field Experience Assignments and the Practicum components for both reading and mathematics. Failure to receive an 80% in any of these six components will result in a D or F average, regardless of the candidates final EDUC 321 grade average.

Course Requirements

A. Class Attendance and Participation/Cooperation

- All candidates should attend all classes, be on time, and not leave early. Candidates must sign the attendance chart next to their name before the start of class. It is your responsibility to sign this chart. If you are tardy, please see me at the end of class.
- Both the university-based and field-based experiences are very important elements in this class. Full participation and attendance is necessary in order to complete the requirements for the teaching component. NO EXCEPTIONS! We will address several topics each day so missed classes equate with a lot of missed

information. Unforeseen emergencies do arise; however, YOU are expected to obtain any missed information and materials ON YOUR OWN.

- You will be given one "freebie" absence during the university-based component. Each other instance of tardiness (or leaving early) and absence during the university-based component will result in a deduction of three and five points respectively, from your total mathematics points at the end of the semester. Extreme emergencies will be dealt with on an individual basis and at the instructor's discretion.
- You are also expected to be punctual on days you go into the field. You are considered tardy if you do not arrive at least 10 minutes prior to your scheduled time slot. Tardiness during field-based teaching experiences will result in a 10 point deduction from your mathematics points. Absences during field-based experiences will result in a 20 point deduction from your mathematics points. You must make up the missed field experience day at a date and time that is agreeable with the mentor teacher and instructor. (You will still receive the 20 point deduction.) Extreme emergencies will be dealt with on an individual basis and at the instructor's discretion.
- If you will be absent on a field-experience day you must contact me before your scheduled teaching time. (Leave me a message, if I am not at school when you call.) You must also contact your partner and make arrangements for him/her to teach your lesson. (Remember you will still receive the 20 point reduction in total points.) Materials and lesson plans must be provided in advance so the teaching partner may substitute.
  AN ABSENCE OR TARDY DURING FIELD EXPERIENCE IS VERY SERIOUS.
- Etiquette: Because class will be conducted at the field experiences school, you are expected to dress in a professionally appropriate manner everyday. No shorts, Capri pants, jeans, sleeveless shirts, gum or children allowed. (This applies regardless if the mentor teacher follows proper etiquette.) Candidates are expected to follow the school's dress code that can be found at the Tangipahoa Parish School System's web site: http://www.tangischools.org/info/dresscode.html. Candidates arriving at school dressed inappropriately will be asked to leave and will be considered absent for the day. Shirts should be long enough as I should not be able to see any of your midsection if you raise your hands or bend over to help a student. Pant legs should not drag the ground. A respectful attitude toward instructors, fellow candidates, mentor teachers, students, and administrators is required. Maintaining confidentiality is also required. An official Southeastern Louisiana University nametag must be worn each day. (These may be purchased at the bookstore.)
- Class participation/cooperation includes attendance, appropriate attitudes, professionalism, responsiveness, and involvement. Assessment of attitudes, professionalism, etc. will be left to the instructor's discretion and points may be subtracted from practicum or overall points as deemed appropriate by the instructor.

- Faculty may not drop junior and seniors for nonattendance, so all candidates must initiate the drop procedure if they wish to withdraw from the course. **Note: The last day to withdraw from regular classes is________________.**

B. University Based Assignments

- Student Information Sheet – To be completed in class.
- Syllabus Verification Form – EDUC 321 Syllabus (online – see Instructor's web site). The verification form must be signed once you have read and understood this syllabus and the Generic EDUC 321 Syllabus.

- Topic Questions – Prior to coming to class you are to read the pages that will be discussed on that day. You are to write using script or print to answer the questions for the given chapter(s). These will be checked at the **beginning** of each class. These questions should serve as a partial study guide for tests.
- Mathematics Autobiography – Write an autobiography about your mathematics life (maximum 2 double-spaced typed pages.) Think about your mathematical experiences from your earliest days to the present.
  1) Write about your best, and worst math experiences.
  2) Identify one concept in math you feel you still do not understand.
  3) Describe any math phobia you may have.
  4) Describe how you really feel about doing math yourself.
  5) Describe your feelings about teaching mathematics to 1^{st} – 8^{th} graders.
- Test #1– This test will be a written component based on knowledge gained through class activities/discussions, textbook readings and field experiences.
- Article Reviews/Critiques – You will be required to read three articles related to the teaching of mathematics. These articles can be found in journals such as Teaching Mathematics in the Middle School and other NCTM journals. You will copy and read the article and then write a reflection/critique regarding the article describing your reaction to the article and the benefits to teaching mathematics. The critique must be at least one but no more than two double-spaced typed pages and the article read must be attached to the critique. NOTE: Be sure it is an article and not just a column. Articles are usually a minimum of 3 pages long.
- Oral Presentation - This will be an oral assessment on performance tasks related to operations on whole numbers and fractions and fraction concepts.
- Test #2 – This test will be a written component based on knowledge gained through class activities/discussions, textbook readings and field experiences.
- Final Exam – This exam will be a take-home exam and will require an application of the knowledge gained throughout the semester rather than a mere memorization of facts.

C. Field-Based Assignments

- Teacher Observation – These reflections are based on your observations during the first two MATH days in the field experiences classroom. A form for each day can be found on Blackboard. Remember this is a reflection and should not simply be an account of the events that took place in the classroom. This assignment is due via email before 9:00 am the day following the observation.

- Once-a-Week Teaching Reflections - You will be required to complete two reflections associated with your weekly teaching experiences. Forms are available on Blackboard for completion of these reflections. Remember that this is a reflection and should not simply be an account of the events that took place in the classroom. This assignment is due via email before 9:00 am the day following your teaching experience.
- Lesson Plans – Lesson plans will not be accepted more than one day late. If a lesson plans is not submitted timely, you will not teach. If you do not teach you will receive a zero for that teaching experience. Formats for the lesson plans and general requirements can be found on Blackboard..
- Block Week Teaching Reflections – Using the self-reflection forms found on Blackboard you will complete a reflection each time you teach during block week. This assignment is due via email before 9:00 am the day following your teaching experience during block week.
- Block Week Partner Observation – You will be assigned a different behavior/teaching strategy to observe in your partner's teaching. This assignment is due via email before 9:00 am the day following the observation of your partner's teaching experience and can be found on Blackboard.
- Self Evaluation/Video – You are to have your partner video tape you teaching a lesson. You are to watch yourself teaching by means of the video and then critique and reflect on what you saw. Then you are to turn in the video (REGULAR VHS tape ONLY) and the self-evaluation/critique. A rubric/form for the self-evaluation can be found on Blackboard.
- Mentor Teacher Assessment – Each time you are in the field teaching the mentor teacher will give you a copy of his/her observation of your teaching. These observations along with a final mentor evaluation of your teaching will be included in the assessment.

****ACCOMODATIONS: If you are a qualified candidate with a disability seeking accommodations under the Americans with Disabilities Act, your are required to self-identify with the Office of Student Life, Room 202, Student Union.*****

- Free discussion, inquiry, and expression is encouraged in this class. Classroom behavior that interferes with either (a) the instructor's ability to conduct the class or (b) the ability of candidates to benefit from the instruction is not acceptable. Examples may include routinely entering class late or departing early; use of beepers, cellular telephones, or other electronic devices; repeatedly talking in class without being recognized; talking while others are speaking; or arguing in a way that is perceived as "crossing the civility line." In the event of a situation where a candidate legitimately needs to carry a beeper/cellular telephone to class, prior notice and approval of the instructor is required. Children should not accompany parents to class.

- As per University policy all email correspondence must use the university's email addresses for communication.

- If you have any questions or needs during the semester, PLEASE come see me!! I have high expectations for each of you and am willing to help you in any way I can but do not wait until the last minute to ask for help. Teaching can be a thing of joy and I hope that during this semester you will have a chance to experience that joy!

Appendix E

ORAL PERFORMANCE EXAM

Pre-service teachers completed the oral performance exam individually. Each pre-service teacher chose randomly one problem in each of the following categories. The pre-service teacher then had to demonstrate a teaching strategy that fostered a conceptual understanding of the mathematics concept.

Subtraction of two-digit numbers with regrouping.

(32 - 17) (25 - 16) (45 - 27) (22 - 18) (34 - 19)

Students used based-ten blocks to effectively teach a conceptual understanding of two-digit subtraction with regrouping.

Multiplication with fractions

(1/2 X 3/4) (2/3 X 1/2) (3/4 X 1/3) (1/4 X 2/3) (3/4 X 2/3)

After choosing a card, the instructor would point to one of the fractions and ask the pre-service teacher to identify and explain the parts of the fraction.

Before calculating the result, the pre-service teacher was required to state if the result would be smaller or larger than the second fraction and explain how they knew this. (For example: Is the result of 1/2 X 3/4, smaller or larger than 3/4).

The pre-service teacher would then demonstrate a teaching strategy to simplify the expression.

Division with fractions

(3/4 ÷ 1/2) (1/2 ÷ 2/3) (3/4 ÷ 1/3) (1/2 ÷ 1/3) (2/3 ÷ 3/4)

Before calculating the result, the pre-service teacher was required to state if the result would be smaller or larger than one and explain how they knew this.

The pre-service teacher would then demonstrate a teaching strategy to simplify the expression.

Assessment Rubric for Oral Examination

Oral Presentation Grading Rubric

Topic 1: Subtracting two digit numbers using base ten blocks

Used the term trading not “borrowing”	1
Started removal of blocks from the left	1
Lined up the ones blocks with a ten rod before trading out	1
Subtracts accurately	1

Topic 2: Fraction Concepts

Knows the term for the top and bottom numbers in a fraction	1
Can define the top and bottom numbers in a fraction	2

Topic 3: Multiplying Fractions

Read the multiplication of two fractions using the term “of”	2
Performs operation on the multiplicand	2
Can determine if the answer is > < or = the multiplicand	2
Can explain how they know if it is > < or = the multiplicand	2
Completes the problem accurately	2

Topic 4: Dividing Fractions

Uses “how many groups of” for ÷	2
Can determine if there is at least one group of the divisor in the dividend	2
Can explain how they know if there is a least one group	2
Completes the problem accurately	2

Total possible points 25

Appendix F

Sample Lesson

Topic 18: Area and Perimeter (2 class periods)

Materials:
Geoboards and Rubberbands (one overhead one)
Color Tiles (one set of overhead)
Transparencies:
- Toothpick dot paper
- Cm squares
- Inch squares
- Various polygon shapes
- Geoboard

Overhead Color tiles

Day 1

Lecture:
Perimeter and Area are often confused (sometimes even by elementary teachers)

Perimeter comes from the Latin/Greek origins words peri – meaning around and metron – meaning measure so you are finding the measure around. The measure around a circle developed it's own name from Latin/Greek origins Circumference = circum meaning "round" and ferre meaning to carry therefore circumference means to carry around. Either way you are measuring around an object.

It is important for students to remember this so that they do not get it confused with area which is the measurement of <u>covering</u> a given section (polygon).

For little ones it is easiest to relate putting a fence around a yard is the perimeter and putting grass sod in the yard is area. (ask for some other analogies) What is an easy way to introduce measuring the circumference of a circle or circular objects (we can simply put a string around them and then measure the length of the string linearly)

As students advance 5^{th} or 6^{th} grade we can find pi by taking the circumference of a number of objects and dividing by the diameter or twice the radius. We can then introduce the formula of $d\pi$ or $2\pi r=C$

Discuss the distance between two points and demonstrate how terms of measurement can be used interchangeably.

It is important to note that length, width, height, depth, altitude etcetera are all terms that measure the distance between two points. These terms help us to explain the manner in which we are measuring but often these terms can be used interchangeably.

For instance, a plane at an altitude of 2000 feet can hit a mountain with a height of 2500 feet. The height and the altitude are describing a measurement to or from the earth to the object.

Length and width can also be used interchangeably. Length usually refers top to bottom and width side to side but it is all relative, and it is important for students to realize this. For instance the length of a ship is front to back and top to bottom is it's height. So, you can see why this can be very confusing to students if you don't let them in on the secret that length, width, height etc just depend on the objects you are measuring between.

Area refers to a numerical measure of two-dimensions in a plane. For example length and width OR height and width or base and height. It is always results in a squared unit of measure. Squared inches, squared feet etc.

Demonstrations:
Pass out supplies and do the following demonstrations with students using their own materials to aid in following the demonstration.

Demonstrate perimeter and area using the geoboards and rubber bands.
Demonstrate using color tiles to represent area and corresponding perimeter.
Demonstrate using dot paper and cm squares paper find the area and perimeter of various rectangles.

Activity: Give each group one of the following problems.
a) What are the possible area measurements of a rectangular yard with a perimeter of 40 feet? Explain

b) What are the possible perimeter measurements of a rectangular yard with an area of 30 square feet? Explain
c) If you double the length and width of a rectangle what happens to its area? Explain
d) If you double the area of a rectangle what happens to its perimeter? Explain

Extensions: a) When does the largest area occur? Is this always true? Explain.
b) When does the largest possible perimeter occur? Is this always true? Explain
c) What if you triple the perimeter? Can you find a pattern?
d) What if you triple the area? Can you find a pattern?

Discuss findings of the activities.

Finish up with the exploring area on the geoboard. Let them take the geoboards home and return them tomorrow. Given a perimeter of 20, how many different areas measurements can you create? Describe the relationship between area and perimeter of rectangles.

Day 2:

Materials:
Scissors, Marker and Blank Paper (about 3 sheets per student)
Overhead transparencies of square cm graph paper, enough for ½ of the students.
Worksheets containing various shapes including those with curved edges.

In the last class, we discovered the relationship between area and perimeter of rectangles. Today we will be finding the areas of various quadrilaterals and the relationship to perimeter.

It is important to note that all quadrilateral areas involve multiplying the base X height and that the base and the height must always meet at a right angle. I tell students it should make an h.
Demonstration/Activity:
First let's find the area of the paper. (Rectangle) = length X height (Write on board)

Mark each of the right angles with a box. Now I want you to form two triangles with your rectangle without cutting the paper. (Fold the rectangle in half diagonally). How much of the rectangle is a triangle? (1/2) Okay so then what is the formula for the area of a triangle (=1/2 base times height This helps to develop the idea of where the formula ½ base X height comes from.) You could say ½ length X width and it would be the same or ½ the width X length.

Paper cutting activity:
We have found from the previous lesson that we can change the shape of objects and get the same area. Unfold your piece of paper and cut it from one vertex to anywhere on the opposite side (not to the opposite vertex!)

Can you create a parallelogram from the two pieces? Is the perimeter the same as for the rectangle? Why or why not? Using the right angles develop a formula for area of a parallelogram.

Can you create a trapezoid from the two pieces? Is the perimeter the same as for the rectangle? Using the right angles develop a formula for area of a trapezoid. (Prompt: Since you have two base measurements, how can you find the average of the two base measurements) This is usually difficult to understand so a demonstration of how to develop the formula is sometimes needed. Now turn it back into a rectangle. In every case, the shape looked differently and had a different perimeter but always had the same area.

Now let's try estimating area of unusual shapes using a square mm grid transparency. Using your square cm graph paper, estimate the area of the shapes on the worksheets. Please be sure to explain your reasoning.

With your group come up with at least one other way to estimate the area of unusual shapes. (Student usually use the concept of covering the shape with an object of known area to estimate.) Explain your method and reasoning.

Discuss solutions to the activities.

Extension: If time permits explore Pick's Theorem using the geoboard paper.

Appendix G

Interview Question Guide

Initial Question: What are some of the aspects of the course that you feel may have aided in this increased conceptual understanding?

Probing Questions: If one of the following areas (underlined and bolded) are not addressed, the corresponding probing question may be used to elicit more information.

What role did the **models or manipulatives** play in helping you to understand certain math concepts?

What role did **class discussion** play in helping you to understand certain math concepts?

What role did **small group discussion** play in helping you to understand certain math concepts?

What role did **oral presentations** play in helping you to understand certain math concepts?

What role did **class demonstrations of activities** play in helping you to understand certain math concepts?

What role did **creating lesson plans** play in helping you to understand certain math concepts?

What role did your **field experience** play in helping you to understand certain math concepts?

What role did your **textbook** play in helping you to understand certain math concepts?

Concluding Question: What suggestions would you give to a new instructor of EDUC 321 regarding helping students to understand math concepts better?

Appendix H

Emergent Theme Matrix

Purpose: to facilitate comparison and synthesis

Increasing Conceptual Understanding of Mathematics

Amanda	4 the inductive approach giving you the problem and trying to figure it out 10 it's easier for a student to understand and see digits and tens then trying to count in their head 15 it helps you to see the relationship between them 19 I like to hear other people's opinion on how they did it 21 their justifying how they got that answer and then myself internalizing and trying to figure out if that was reasonable or logical 27 tried to explain why you did what you did 34 they're scared to discuss it 37 they might know more than they think 46 you would have to start all over and rethink and try to get your mind straight 48 they say do that and this, instead of trying to understand why 52 you actually had to sit there and think, step by step what to do 54 you had to explain why you did it that way and actually solidify and justify the answers 58 you had another perspective 60 gave us a visual about another option 68 we need to know that, um, there is a logical reason for doing this before this and how they correlate with each other 87 I really had to demonstrate the reason behind it 102 It was probably the written expression, the how and the why 104 so I could internalize why I was doing it and you know understand how I was doing it in my head 106 I know why but it was hard for me to explain why 108 to understand what are the moves and then you take it a step further 113 it probably helped me more because it was just

	reinforcing what I already knew 136 explain why you can do it rather than what are the five levels of… 157 I increased more was because I was refreshing my mind
Gretchen	6 she would show us how to do it but me and the girl that sat next to me we were always done by the time she got finished explaining 8 she would really explain things 14 we would just figure out how to do it 16 then the people next to us would ask us well how you do it and when we showed them they would say "that's all you do" 24 she would show you a couple of different ways 25 she would show you the shortcuts 26 discuss things and figure it out a little bit 35 so I think by seeing some of the stuff done with the manipulatives it helped me remember it a little bit better 50 to hear what other people were saying 51 I actually got up and said why I thought it went a certain way and that helped me learn the way 53 I was doing it a little better because I was showing other people how to do it 57 we got to discuss it with each other and figure it out on our own how certain things work 63 it was more like having to figure it out on our own 77 the practicing helped me to understand it a little bit more 85 I could see 86 a lot of times I would try to figure out what you were going to do with it 88 it made me think because I was trying without watching you 94 it helps you understand it a little better 109 because you have to take all the information you know about something and make it smaller 115 the more hands on activities and stuff helped students understand it 120 with more time they probably would understand it on paper too 122 if we had more time to connect it to each other they

		would have understood it a lot better
	136	everything was hands on so we actually got to learn a little bit more
	143	use as many hands-on things they can to help the students understand it
	144	a lot of discussion that dealt with what they were doing, not just how to do it
	146	let them tell you why they think something
	148	they might realize, oh wait, why do I think that
	150	let everybody explain why they're doing something
	158	it was very important for them to explain why
June	17	if I don't understand something like I really can't move past it
	18	I really need to know why
	19	like they didn't know the answer themselves to explain it to me
	21	they knew how they did it, but they couldn't tell me why it was
	33	I was teaching myself
	38	I would look at them and figure out how to get the answer
	39	I would just figure out how to do it
	44	being forced to think conceptually
	46	I did it this way and I really didn't know why
	48	having to teach myself and teach someone else
	51	why you do things I think that really helped
	57	I wish I would have been shown that way as a child but everyone just said this is the way it is
	60	I could see it visually
	68	I always though that whenever I hear it and whenever I have to explain it to someone else that's when I really get it
	77	it makes me think. If I have to explain it to someone else it makes me know why and it makes me kind of search for the reason
	82	It helps me to remember it more whenever I'm telling someone else about it
	83	it forces me to think
	89	tell them what I knew
	91	it really boosted my confidence
	93	it helped me to remember and it made me think, you

	know, why 103 I never knew, you know, how that worked 105 having to explain it and break it down and that helped 115 they never had anything to show me 122 ya'll are going to do this and this is why 126 breaking it down step by step I found really difficult 131 yeah it definitely made me know how to do it 133 to break it down and show them how to do it 140 I didn't realize now how much I didn't know 142 I couldn't think of a way of how to relate it to them 158 discussion helped me a lot more 159 I won't get nearly as much out of the book as I do from hearing it 169 I had no idea how to relate thing to them 194 explaining the concept to someone else that is difficult
Hailey	5 there were some things I know better connections on 8 it made a log more sense 9 like trying to figure it out 27 some people who are visual it's very helpful for them to be able to see 35 trying to figure it out 40 it was definitely helpful to talk with my partner 54 why did you do things that way 63 explain things 64 it helps to be able to take what you are thinking and put it into words 69 put on a completely different mind set 73 talk about it and you know listen to myself and hear how my thought processes are going 89 it helped me to think a little bit harder 91 start thinking about things from more than just my perspective 121 it was really hard for me to wrap my mind around that 141 cause I grew up with that memorization um way of thinking 143 when I was in there doing the activities and enjoying them then I'm learning 147 doing the activities was better than just seeing em

Appendix I

EXIT SURVEY - EDUC 321

1. Has taking this course aided you in increasing your conceptual understanding of the mathematics concepts presented?

a. no, not at all	b. yes, somewhat	c. yes, greatly

2. Please place in order by numbering the components of the course you felt aided in developing a conceptual understanding. If the component did not help leave it blank.

_____ discussions, whole class and small group

_____ textbook

_____ field experience

_____ demonstrations of strategies, with and without manipulatives

_____ using the manipulatives, individually and small group

_____math articles

_____ creating lesson plans

3. What concept did you have a better understanding of since taking this class? (Circle all applicable)

adding fractions	adding numbers	probability
subtracting fractions	subtracting numbers	data analysis
multiplying fractions	multiplying numbers	quadrilaterals
dividing fractions	dividing numbers	triangles
comparing fractions	area	perimeter
solving equations	simplifying expressions	circumference

SOUTHEASTERN
LOUISIANA UNIVERSITY

Institutional Review Board
Box 11851
Phone: 549-2077

Campus Correspondence
www.selu.edu/Academics/OSRP/IRB.html
Fax: 549-3640

DATE: April 28, 2003

TO: Patricia Edmiston

FROM: Dr. Michelle Hall, Chair

RE: IRB Action on Proposed Project

This memo is to inform you of the IRB action with regard to your proposal:

Title: Investigating the Changing Perceptions of Pre-service Teachers Enrolled in a Mathematics Methods Course

This proposal was given: Expedited Review:______

Full Committee Review:__X___

Exempt:______

The result was: Full Approval:__X___

Denied Approval:______

If anything other than Full Approval is recommended, it is your responsibility, as investigator, to submit changes/corrections or plans to accommodate conditions listed below to the Office of Sponsored Research and Contracts prior to initiating the project.

Failure to acquire full approval by IRB before implementation for any project which involves humans or live vertebrate animals means that the PI is not acting in "good faith" with university policy and is not, therefore, guaranteed the protection of the university.

Committee Comments:

IRB Number:2003-075

UNIVERSITY OF NEW ORLEANS
COMMITTEE ON THE USE OF HUMAN SUBJECTS

Form Number: 8FEB04 ***(please refer to this number in all future correspondence concerning this protocol)***

Principal Investigator: Patricia F. Edmiston **Title:** Graduate student

Department: Curriculum & Instruction **College:** Education & Human Performance

Name of Faculty Supervisor: Richard Speaker***(if PI is a student)***

Project Title: Investigating the changing mathematical conceptual understanding of pre-service teacerhs enrolled in a mathematics methods course

Date Reviewed: February 8, 2003

Dates of Proposed Project Period: From 12/03 to 12/04
***approval is for one year from approval date only and may be renewed yearly.**

Note: Consent forms and related materials are to be kept by the PI for a period of three years following the completion of the study.

☐ **Full Committee Approval**

☑ **Expedited Approval**

☐ **Continuation**

☐ **Rejected**

☐ **The protocol will be approved following receipt of satisfactory response(s) to the following question(s) within 15 days:**

Committee Signatures:

____________________ Scott C. Bauer, Ph.D. (Chair)

____________________ Anthony Kontos, Ph.D.

____________________ Betty Lo, M.D.

____________________ Jayaraman Rao, M.D. (NBDL protocols only)

____________________ Laura Scaramella, Ph.D.

____________________ Richard B. Speaker, Ph.D.

____________________ Gary Talarchek, Ph.D.

VITA

Patricia Flad Edmiston was born in New Orleans, Louisiana. She earned her undergraduate degree in Mathematics Education from the University of New Orleans, and her Masters Degree in Science Teaching from Loyola University in New Orleans. She is also certified to teach academically gifted students.

She has worked as an administrative assistant, an adjunct instructor at Tulane University, taught mathematics, science and gifted education at two public schools, and has conducted workshops on mathematics and higher order thinking skills for school teachers. She has also served as a LATAAP mentor teacher. She currently teaches a mathematics methods course, as well as, introduction to education, and diversity in education courses at Southeastern Louisiana University in Hammond, Louisiana.

She lives in the quaint town of Abita Springs, Louisiana with her husband Ron, an elementary public school teacher and business owner, and her son Austin, a junior at Fontainebleau High School.