Exploring the relationship between teachers' beliefs in mathematics and their instructional practice

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EXPLORING THE RELATIONSHIP BETWEEN
TEACHERS' BELIEFS IN MATHEMATICS
AND THEIR INSTRUCTIONAL
PRACTICE

by

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ABSTRACT

Exploring the Relationship Between Teachers' Beliefs in Mathematics and Their Instructional Practice

by

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This study explored the relationship between teachers’ beliefs about mathematics and their instructional practices. The personal epistemology of the case study elementary mathematics teachers was documented and analyzed to provide evidence of the connection between teachers’ beliefs and practice in an elementary school setting.

This study was grounded in a theoretical framework of epistemological world views, particularly the comparison of belief across three epistemological world views: 1) the realist, 2) the contextualist, and 3) the relativist. Three areas of beliefs are addressed in this study: 1) beliefs about curriculum, 2) beliefs about pedagogy, and 3) beliefs about assessment. Through analysis of these beliefs specific to mathematics, this study identified which world view the case study teachers espouse and how this influenced each teacher’s mathematical classroom practice. This study sought to answer the following research questions:

1. What are teachers’ beliefs about curriculum, pedagogy, and assessment?
2. What practices provide evidence of teacher beliefs?

3. What is the relationship between teachers’ beliefs in mathematics and their instructional practices?

This design of the study was a qualitative case study. Participants in this study were three third grade teachers from different schools in the same school district located in the southwestern United States. These teachers provided the unit of analysis for the study. The schools were selected because they support a standards-based approach to mathematics mandated by state and district standards. The teachers selected for the study use similar third grade resources to implement standards-based mathematics curriculum in the elementary classroom. The participants’ perspectives are shared through interviews, observations, documents, and audio-visual materials. In this study, the teachers’ epistemological world view was examined and compared to their implementation of mathematics practices.

From the domain analysis, many factors supported and hindered practice based on the world view of the teachers. The researcher categorized these domains based on broad external factors to narrow internal factors. The following domains were examined based on the data: 1) domain one: school district factors, 2) domain two: school culture factors, 3) domain three: physical classroom factors, and 4) domain four: individual teacher beliefs.

Implications from this study included a need to: 1) provide teachers with an understanding of mathematic content and an understanding of beliefs about curriculum, pedagogy, and assessment, 2) provide courses for pre-service teachers and teachers that incorporates a comparison of world views into the mathematics coursework, 3) support
collaborative efforts between teacher educators and school districts in designing a shared vision for world views, and 4) inform the mathematics domain in regards to world views to improve teaching.
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CHAPTER 1

INTRODUCTION

In a mathematics classroom, students are seated in single rows separated from one another, the teacher positioned at the front of the classroom. The teacher is instructing how to add double-digit addition problems on the boards by having students start at the right and add the digits, followed by putting the ones from the answer under the problem and carrying the tens to the next column. The teacher explains the specific procedure used to solve the addition problem on the board. Students are quiet; however, they are occupied with daydreaming, writing notes to a friend, or looking out the window for something to catch their attention. The teacher poses yes or no questions to the class and proceeds to assign 25 problems similar to the ones she completed on the board. The bell rings and the students file out the door for recess.

The learning environment described above is teacher directed with little or no student involvement. Instant recall of facts is stressed and procedural knowledge valued. Students can follow the process; however, no conceptual knowledge of the mathematics is demonstrated. Many researchers (Klein, 2003; Quirk, 2004; Ross, 2001) endorse this more traditional approach to mathematics. The following fictional vignette provides a hypothetical classroom observation, illustrating an alternative perspective to teaching mathematics, one focusing on student-centered approaches to learning (National Council of Teachers of Mathematics, 2000).
Upon entering the classroom, the students are seated on the floor in front of the whiteboard. The teacher is seated in a chair directly in front of them. The teacher presents the class with the task for the day: “I have seven things on my plate. Some of them are peas and some are carrots. What do I have? How many peas and how many carrots?” The students are then divided into groups to solve the problem. Some choose to use cubes while others draw pictures on paper. The teacher calls the students back to the floor to share the solutions. As the students share strategies, the teacher records their comments on the board and models the students’ work using both cubes and pictures when appropriate. The lesson continues by having more students share, ultimately leading to a discussion of misunderstandings and misconceptions.

What is the best way to instruct future educators wishing to teach children mathematics? This is a growing debate among educators in the field of mathematics. There are those who endorse a traditional, teacher-centered approach to the learning environment, while others argue for a more hands-on, constructivist, and student-centered focus in the classroom.

Purpose of the Study

In order to understand teachers’ approaches to classroom practice, this study explored the relationship between teachers’ beliefs about mathematics and about mathematics instruction. The personal epistemology of the case study elementary mathematics teachers was documented and analyzed to provide evidence of the connection between teacher beliefs and practice in an elementary school setting.
Background

Need for Three Epistemological World Views

Epistemology is the part of philosophy that is about the study of how we know things (Cambridge Dictionary, 2004) and includes “beliefs about the definition of knowledge, how knowledge is constructed, how knowledge is evaluated, where knowledge resides, and how knowing occurs” (Hofer & Pintrich, 1997, p. 4). Researchers need to examine how teachers’ views of learning affect the classroom environment. In the 1970s, Perry’s seminal work provided the basis for epistemology research and has since been modified by other researchers to develop subsequent models of epistemology. Hofer and Pintrich (1997) provided a comprehensive review of the different epistemological research programs. For the purpose of this study, the epistemological worldview is defined as teachers’ collective beliefs about the nature and acquisition of knowledge (Schraw & Olafson, 2002). Schraw and Olafson (2002) proposed that individuals identify with one of three unique world views: realist, contextualist, and relativist.

Each worldview is unique, based on how an individual views a particular set of beliefs. For the scope of this paper, world views will be defined and analyzed through teacher’s beliefs about curriculum, pedagogy, and assessment. Where the realist believes knowledge is gained passively from experts within a domain such as mathematics, realists endorse deliberate practice and utilize standardized test for means of assessment. The contextualist believes individuals construct knowledge thereby endorsing a constructivist approach to learning. Central to this approach is producing an environment that is interactive and exploratory for learners. Students build a community of learners by cooperating to construct knowledge. The goal of learning for the relativist is to produce self-regulated individuals. Subject matter is changing due to individual, prior knowledge
and area of interest (Schraw & Olafson, 2002). This means math is viewed as constantly changing by the knowledge acquired by an individual. This study identified which worldview the case study teachers espouse in relation to mathematics practice.

The State of Mathematics Education

National standards for mathematics education have evolved from current reform efforts emphasizing the importance of teacher knowledge (National Council of Teachers of Mathematics, 1991 & 2000). The National Council of Teachers of Mathematics (NCTM) standards consider improvements in professional development for teachers, program development, and enhancing student learning by promoting constructivist learning environments. The movement towards standards-based mathematics education, however, is not supported by all educators (Klein, 2003; Quirk, 2004; Ross, 2001). One such group is Mathematically Correct (2005), which opposes the national standards movement in order to promote quality in mathematics education. Due to the recent reform efforts, this group feels that students have less and less exposure to rigorous, content-rich mathematics. Mathematically Correct (2005) calls for a back-to-basics movement in opposition to the standards-based movement endorsed by NCTM. This math war is a major issue in today’s mathematics education. In order to develop an understanding of the relationship between teachers’ beliefs in mathematics and their instructional practices, the implementation of standards-based mathematics must be addressed. A teacher’s worldview will provide information as to how mathematics curriculum is interpreted and implemented in classroom practice. Teachers continually seek ways to raise the academic achievement of students in the classroom and standards-based reform supports improved teaching as a way to increase learning (Birman, Desimone, Porter, & Garet, 2000). Improved teaching efforts are based on the standards-based movement.
Since the mid-1980s there has been a movement toward mathematics reform. For a change in the teaching of mathematics to be successful, the NCTM identified a shift that needs to happen. First, students must build “mathematical communities” (p. 3) by working together to solve problems. Second, the teacher is no longer the sole source of information because students use “logical and mathematical evidence as verification” (p. 3) for constructing knowledge. For example, a student believes that $2 + 2 = 4$; however, simply providing this answer is not sufficient. The student must use justification to defend how the answer was determined. This might occur though the use of pictorial and/or concrete representations. Third, the student must demonstrate “mathematical reasoning” (p. 3) instead of just recalling memorized procedures. The question why does $2 + 2 = 4$ is examined by students; therefore, the child can provide a justification. Fourth, students “conjecture, invent, and problem solve” (p. 3) in order to determine answers rather than memorizing step-by-step procedures. Lastly, students are “connecting mathematics, its ideas, and its applications” (p. 3), as opposed to viewing problems in isolation. The child who understands $2 + 2 = 4$ can use that information to solve other similar problems such as $2 + 3 = 5$ (NCTM, 1991). This validates a contextualist approach to mathematics instruction because the emphasis is directed at students creating their own strategies for problem solving. This differs from knowledge of rote memorization of basic mathematic facts because students must explain conceptual understanding of the concept instead of recalling the answer.

*Principles and Standards for School Mathematics*, published by the NCTM (2005), provides guidance for specific curriculum decisions made at the local level. One of the
goals of the NCTM document is to guide the development of curriculum frameworks, assessments, and instructional materials. These principles and standards provide educators and policy makers a reference for designing state standards and local district curriculums. Mathematical understanding, knowledge, and skills that students should acquire through pre-kindergarten through 12th grade are described in the NCTM document. The standards for mathematics are broken into content standards and process standards. The five content standards are: number and operations, algebra, geometry, measurement, and data analysis and probability and explicitly describe the content that students should learn. The process standards are: problem solving, reasoning and proof, communication, connections, and representation. These standards provide examples of what standards-based mathematics should look like in practice and what the teacher’s role should be in implementing these standards. Hence, in the United States, many state and local school districts adhere to the mathematics curriculum based on the mathematical standards described by NCTM.

Statement of the Problem

Elementary school teachers are required to include mathematics instruction daily in the classroom. The curriculum mandates that all teachers are required to teach specific areas of mathematics for a particular amount of time in the elementary classroom; however, it does not mandate how the curriculum should be implemented. The teacher must interpret these standards in order to address mathematics instruction in the classroom. This study seeks to understand the relationship between teachers’ beliefs and their subsequent interpretation of national standards as represented by their instructional approach to mathematics.
Questions Guiding the Study

This study sought to answer the following research questions:

1. What are teachers' beliefs about curriculum, pedagogy, and assessment?
2. What practices provide evidence of teacher beliefs?
3. What is the relationship between teachers’ beliefs in mathematics and their instructional practices?

Significance of the Study

This research project provides insights into the views of teacher beliefs and how a teacher’s espoused worldview impacts mathematics practice. Descriptions of the relationships between teachers’ stated beliefs and actual mathematics practice have value for educators interested in teacher beliefs within specific domains. This research is novel because it examines teacher beliefs through world views as they specifically relate to teaching and learning mathematics. Practical significance of this study centers the influence of professional development and teacher education problems specific to mathematics education. The results from this study could be used by universities and school districts to design professional development and make decisions regarding curriculum revisions in mathematics methods courses for teacher educators.

Theoretical Framework

This study is grounded in a theoretical framework of epistemological worldview, particularly the comparison of beliefs across three epistemological world views described by Schraw and Olafson (2002). Three areas of belief will be addressed in this study: 1) beliefs about curriculum, 2) beliefs about pedagogy, and 3) beliefs about assessment.
Through analysis of these beliefs specific to mathematics, this study will identify which world view the case study teachers espouse and how this influences each teacher's mathematical classroom practice.

Table 1. Theoretical Framework: Epistemological World Views (Schraw & Olafson, 2002)

<table>
<thead>
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<th>Three Beliefs</th>
<th>Realist</th>
<th>Contextualist</th>
<th>Relativist</th>
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<tr>
<td>Beliefs about curriculum</td>
<td>Curriculum is viewed as statistic and unchanging</td>
<td>Curriculum is changing and student-centered</td>
<td>Curriculum is not standardized but instead focuses on specific student's interest</td>
</tr>
<tr>
<td>Beliefs about pedagogy</td>
<td>Teacher-centered instruction</td>
<td>Student-centered instruction</td>
<td>Individual centered instruction</td>
</tr>
<tr>
<td>Beliefs about assessment</td>
<td>Norm-reference testing</td>
<td>Multiple forms of assessment</td>
<td>Individual assessments</td>
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</table>

Beliefs About Curriculum

Curriculum is interpreted differently throughout the three world views. The realist views the curriculum as static and unchanging. Knowledge is gained through curriculum determined by experts in each domain. A domain refers to the specific area of content such as mathematics. The curriculum serves as the basis for teachers to teach skills to students. The realist teacher endorses directed, traditional, skills-based textbook approaches to teach mathematics curriculum (Kids Do Count, 2005). Conversely, contextualist teachers conversely view curriculum as changing and student-centered. By allowing students to construct knowledge as learners, the educational goal is to help them think critically about concepts (Goldin, 1990). Through student-centered learning
opportunities such as inquiry-based learning, students construct knowledge that is relevant to the specific task and/or situation. The contextualist teacher would endorse the NCTM standards as a vehicle for teaching mathematics because it promotes a focus on student-centered learning.

For the relativist teacher, knowledge is relative to each individual student. The curriculum is not standardized, but instead focuses on a specific student’s interest. A relativist teacher would find it difficult to exist within a school district that mandates a standard curriculum framework. Relativists make choices regarding curriculum, pedagogy, and assessment in terms of what is needed for each specific student. A curriculum that mandates one set of standards for all children would oppose the philosophy of relativists.

Beliefs About Pedagogy

Pedagogy, the way curriculum is implemented in the classroom, would depict different situations according to the three world views. Pedagogy is the study of the methods and activities of teaching (Cambridge Dictionary, 2004). Realists believe learning is transferred in a programmatic fashion from teachers to students. The role of the teacher is to disburse knowledge to the students in a lecture format. Textbook directed lessons are the foundation of teaching. Students are taught and required to master the traditional algorithms in mathematics (Ross, 2001). The realists mirror the philosophy of perennialists that see the aims of education as the discipline of the mind, the pursuit of truth, and the development of the ability to reason. Perennialists view truth as eternal, everlasting, and unchanging. Education serves to inform students of knowledge that will remain constant through life (Oliva, 2005).
Contextualists believe individuals construct knowledge with other students in the classroom. Constructivism is built on the principle that students actively create, interpret, and reorganize information in ways that are unique to each individual (Brewer & Daane, 2003; Cobb, 1996; Goldin, 1990; Windschitl, 1999). The fundamental idea of constructivism is allowing students to connect to the learning environment through problem-based learning, inquiry activities, and dialogues with others. Students should experience learning through ideas, phenomena, and artifacts of the discipline before having formal explanations of them. Constructivist teaching is not prescriptive but, instead, is more about responding to the needs of a situation. There are many strategies that a teacher might employ when teaching a particular content area: 1) scaffolding, which allows the learner to make sense of a complex task; 2) modeling, which requires the teacher to think aloud about problem solving; while 3) coaching, guiding, and advising require the teacher to probe the students’ thinking. The teacher’s role is that of a facilitator of learning who responds to the students’ needs in a flexible manner (Windschitl, 1999). NCTM promotes this approach to mathematics learning in the elementary classroom.

Similarities in approaches to student learning exist between the contextualists and the relativists. While relativists support constructivist methods of teaching, differences occur due to the focus on individual students rather than through peer interactions. Relativists endorse discovery learning through student autonomy. The goal of education for these teachers is to produce self-regulated learners (Schraw & Olafson, 2002). Experiences should be genuine and relevant to the learner. Inquiry is used as an approach for students to engage in personal discoveries. The learning is centered on the student. The interest of the individual is the vehicle for learning the curriculum.
Beliefs About Assessment

Assessment is another dimension that varies between world views. Realists use tests as a vehicle to determine whether students have mastered a concept. Supporters of Mathematically Correct (2005) would promote standardized testing to measure mastery of knowledge and skills, as determined by the curriculum. Norm-referenced or criterion-referenced testing as examples is preferred because students are assessed for mastery on the skills and knowledge mandated by the curriculum. These tests promote a paper and pencil approach to computation of mathematics.

Contextualists' beliefs are reflected in the use of both testing and alternative assessments. The NCTM standards document recommends teachers think about assessment differently than simply using a test to summarize a unit of activity or to assign a grade. It is recommended that assessment be used to guide instruction and allow students to communicate more deeply than a traditional test. Contextualists believe assessments can provide insight into students' feelings and beliefs about mathematics as well as the learners' role in doing mathematics. Schleomer (1997) used mini-projects in her mathematics classrooms as an alternative assessment. Through mini-projects, her students thought about the mathematics concepts in terms of the everyday world. Raymond (1994) uses four means of assessing student learning in the mathematics classrooms: 1) group and individual problem solving exams, 2) group projects, 3) written reflections, and 4) self-assessments. By using multiple forms of assessments, teachers gain a greater understanding of students' mathematical knowledge.

Relativists consider the needs of each individual student in utilizing assessment. Because each student has different goals for learning, assessments must include multiple
modes to demonstrate knowledge (Schraw & Olafson, 2002). Assessments must be intelligent, fair, and domain specific. Student competence and performance can be measured through projects instead of tests. “Projects that are meaningful to students that are of sufficient complexity to stimulate their interest and invite their engagement and take place over time offer students opportunities for developing their understanding and skill in specific domains or across domains” (Haggerty, 1995, p. 51). Haggerty continued Gardner’s work, which involved measuring the results of multiple intelligences by having students create processfolios instead of testing. Through processfolios, teachers gain a realistic basis for assessing students’ performance because the processfolios contain initial plans, false starts, outlines, drafts, sketches, dead ends, turning points, personal likes and dislikes, and final evaluations. Processfolios can also contain records of project presentations as well as ideas and plans for future, related projects. Through processfolios, students can monitor themselves in terms of academic growth and personal reflection (Haggerty, 1995).

Summary of Framework

Schraw and Olafson’s (2002) framework provides a means to compare beliefs across three epistemological world views as they relate to curriculum, pedagogy, and assessment. To enhance this framework, this study will examine beliefs through the lens of mathematics education. The realist, contextualist, and relativist world views suggest different ways of approaching classroom practice. Currently, there is little understanding about the relationship between epistemological world views and teaching practice (Schraw & Olafson, 2002). The goal of this research is to provide a deeper understanding of this relationship specific to the domain of mathematics.
Description of Subjects and Setting

This design of this study was a qualitative case study. Participants in this study were three 3rd-grade teachers from different schools in the same school district located in the southwestern United States. These teachers provided the unit of analysis for the study. The schools were selected because it supports a standards-based approach to mathematics mandated per state and district standards. The teachers selected for the study use similar 3rd-grade resources to implement standards-based mathematics curriculum in the elementary classroom. In this study, the teachers’ epistemological worldview is examined and compared to the implementation of mathematics practices.
CHAPTER 2

LITERATURE REVIEW

The following review of literature contains a detailed description of the main components of the research that informs the study. The study is structured around the idea of how teachers’ beliefs influence mathematical classroom practice. There are three aspects to this examination of teachers’ epistemological world views. They include: 1) beliefs about curriculum, 2) beliefs about pedagogy, and 3) beliefs about assessment. The three epistemological world views that are considered throughout this study include: the realist, the contextualist, and the relativist (Schraw & Olafson, 2002). The study is viewed through the lens of mathematic education, thus furthering the field of research. Epistemological World views have historically been researched through the whole of education instead of an in-depth focus on one domain, which makes this study novel. First, literature of epistemology will be shared. Second, teacher beliefs and mathematics research will be discussed. Third, the review will examine mathematics education.

Epistemology

Hofer and Pintrich (1997) defined epistemology as an area of philosophy that examines the nature and justification of human knowledge. The researcher seeks to understand how individuals come to know, what individuals think about how they acquire knowledge, and how these beliefs about knowledge influence the cognitive processes of
Historically, Perry’s (1970) work pioneers the examination of epistemological beliefs. His work at Harvard examined undergraduates’ epistemological beliefs through interviews and questionnaires. The findings revealed that college students acquired knowledge through an evolving developmental process. As a result, Perry designed a scheme of intellectual and ethical development. The model describes the nature of knowledge and truth through four different positions: dualism, multiplicity, relativism, and commitment within relativism. Dualism is the belief that experts convey truth to the learner. Multiplicity means that all authorities’ views are equal and valid and requires the individual to decide which opinion to endorse. In relativism, the individual is an active seeker of meaning who perceives knowledge as relative, contingent, and contextual. Here, the individual must choose and affirm one’s own commitments. The final position, a commitment within relativism, is where the individual demonstrates responsibility, engagement, and the affirmation of commitment. These commitments are reflected in values, careers, relationships, and personal identity. One criticism to Perry’s research, according to Hofer and Pintrich (1997), was that the majority of participants were college-age males, limiting generalizations made to the overall population of college students.

Belenky (1986) furthered the field by investigating the woman’s perspective. The case study interview data was collected from women enrolled in one of six diverse academic institutions or who were involved in human service agencies. Her model, *Women’s Ways of Knowing: The Development of Self, Voice, and Mind*, gives the epistemological perspective of women in how they know and view the world through the following positions: silence, received knowledge, subjective knowledge, and procedural
knowledge which can be found in two forms: 1) separate knowing and 2) constructed knowledge. Silence pertains to the position that females are passive and listen only to authority figures. Received knowledge refers to the perspective of a right and wrong, which means there exists multiple ideas that can be determined correct or incorrect. Subjective knowing means the source of truth is within the individual. Truth is gained through intuition and/or personal experience. In the final position of procedural knowledge, women show reasoned reflection and use objective and systematic procedures for analysis. This position is divided into two parts, a separate knowing, which is traditional knowledge is gained through critical thinking, where as constructed knowledge promotes an integration of subjective and objective strategies for knowing. All knowledge and truth is based on context. Belenky’s work focused on the source of knowledge and truth. The role of self in relation to others and to knowledge is central to the model.

Baxter Magolda’s (1992) research focused on possible gender-relation implications of epistemology. Thus, her work grew from Perry’s findings in men and Belensky’s study of women. Her five-year longitudinal study of 101 randomly selected students from Miami University of Ohio consisted of conducting open-ended interviews and giving participants the Measure of Epistemological Reflections (MER). This research lead to the epistemological reflection model, which is composed of four different epistemic assumptions about ways of knowing: absolute, transitional, independent, and contextual. Absolute knowers believe that certain knowledge is shared by authority figures. Transitional knowers do not believe authorities know everything, so they begin to understand that knowledge is not certain. Independent knowers view their own opinion as valid as those of authority and begin to question experts as the only source of knowledge.
Contextual knowers examine evidence in a context and then construct a personal perspective of knowledge. This model does not focus on the assumptions about knowledge, but rather addresses the nature of learning in the college classroom context.

King and Kitchener’s (1994) research consisted of interview studies conducted for fifteen years with people from high school through middle-age adults. During the interview, the participants were asked four ill-structured problems. Once the participants answered and justified their response, they were asked six follow-up questions with the purpose of finding out assumptions about knowledge and how it is acquired. This research lead to the development of the reflective judgment model, which has seven stages of development that are divided into three levels: pre-reflective, quasi-reflective, and reflective. In the pre-reflective stages, individuals believe there are correct answers to all problems; whereas, quasi-reflective thinking requires the individual to question what one can know with absolute certainty. Reflective thinkers conversely believe knowledge is actively constructed and must be related to a context. Epistemic cognition, how people understand the process of knowledge and the ways in which they defend their beliefs about ill-structured problems, is the focus of this model (King & Kitchener, 1994).

Kuhn (1991) was interested in the idea of thinking as argumentative reasoning. She wanted to investigate how people responded to everyday, ill-structured problems that did not have one clear answer. The participants in Kuhn’s (1991) study were people in their teenage years, 20s, 40s, and 60s. This was the first time a study involving epistemology had subjects that reflected various age groups. Kuhn’s model (1991) was defined by three categories of epistemological views: absolutist, multiplist, and evaluative. The absolutist perceives knowledge as certain and absolute, whereas the multiplist does not believe that knowledge is certain, but instead believes that knowledge can change over time, meaning
expertise is questionable. The evaluative individual agrees with the multiplist that knowledge is not absolute; however, they believe individuals who have obtained expertise as more knowledgeable than individuals who have not gained knowledge in a particular domain. Evaluativists endorse a belief that there are multiple perspectives as to knowledge in a given field.

Schommer (1990) was interested in epistemological beliefs and how those beliefs impact comprehension and academic performance. The tool used in this research was a questionnaire that listed statements pertaining to epistemological beliefs. By conducting a factor analysis, the study yielded four factors that are viewed as a continuum: fixed ability, quick learning, simple knowledge, and certain knowledge. Fixed ability is a belief that intelligence is either something an individual is born with or that it can be increased with time through environmental factors. Quick learning refers to the speed at which an individual is able to learn something. Simple knowledge can be viewed as knowledge consisting of isolated information rather than viewing knowledge as interrelated concepts. Certain knowledge ranges from knowledge being viewed as absolute truth to knowledge being constantly changing and evolving.

These findings provided a foundation for further exploration into the idea of an epistemological belief system (Schommer-Aikins, 2002). By examining a set of beliefs and knowledge acquisition that influences the way teacher a thinks and makes instructional decisions, a researcher can determine an individuals' epistemological worldview (Schraw & Olafson, 2002). Pajares (1992) stated that beliefs of teachers should be a focus of education research because it can inform educational practice. The basis of this study will examine teacher's beliefs in the domain of mathematics education. The next section will address teacher beliefs and mathematics.
Literature Review Procedures

A systematic search through computerized databases—Cambridge Scientific Abstracts Multiple Database, Education Resources Information Center (ERIC), and Academic Search Elite (EBSCOhost)—was conducted. In addition, a search was conducted with the Google internet search engine. A search of the University of Nevada, Las Vegas (UNLV) library catalog was performed. The following descriptors were used: teacher and epistemology and math, teacher beliefs and mathematics, standards-based mathematics, and traditional mathematics. An ancestral search through the reference lists of the articles obtained in the computer search also was completed. The selection criteria for studies that were included in the review of literature were based on their relevance to the purposes of the study: 1) to investigate the relationship between teachers’ beliefs in mathematics and their instructional practices and 2) to describe how teachers’ beliefs affect the interpretation of national mathematics standards.

Teacher Beliefs and Practice

According to Thompson (1992), a relatively new topic of study is that of the nature of teacher’s beliefs about mathematics and teaching and learning. Although research has been done to examine the development of students’ epistemological beliefs (Hofer & Pintrich, 1997; Muis, 2004), limited research has been done to examine the development of teachers’ epistemological world views and beliefs. More research is needed in order to determine if these beliefs influence teachers’ instructional practice. Many researchers believe that teachers’ beliefs about the teaching and learning of mathematics does impact their practice (Fennema & Franke, 1992; Ernest, 1988; Thompson, 1984); however, others (Levitt, 2001; Shirk, 1973; White, 2000; Wilcox-Herzog, 2002) believe that there are inconsistencies between teachers’ beliefs and teaching practice. The following
research informs the reader of current studies that address this debate among educators and researchers involving teacher beliefs and practice.

**General Teacher Beliefs**

Both Levitt (2001) and Schraw and Olafson (2002) found that although many teachers espouse a student-centered constructivist approach to teaching, teachers still rely heavily on district mandated curriculum and assessment for instruction, not recognizing the philosophical conflict. Wilcox-Herzog (2002) conducted a study to examine the link between beliefs and behaviors for early-childhood teachers. The participants of the study consisted of 47 early-childhood teachers who were primarily female and worked with children ages 3-5. A self-report questionnaire was used to measure teaching beliefs. The results demonstrated that there was not a relationship between teachers' beliefs and classroom practice. Schraw and Sinatra (2004) encouraged future researchers to investigate the beliefs and classroom practice of teachers.

Other researchers examined teaching and learning epistemologies within specific content domains. Johnston, Woodside-Jiron, and Day (2001) examined the relationship between teacher epistemology, classroom interactions, and related student epistemologies in literacy. Four cases detailed the link between teachers' epistemological stances and those of their students. The data consisted of interviews and classroom discourse analysis. Findings suggest that discourse environments have a strong influence on the development of children's epistemologies.

Levitt (2001) examined the beliefs of elementary teaching in regards to the teaching and learning of science. She sought to determine the extent to which the teachers' beliefs mirrored that of science education reform. The participants consisted of 16 teachers from two school districts that were involved in a local systemic initiative for science education.
reform. The teachers were each observed teaching a lesson from the science program, which then served as the context for the follow-up interview with the teacher. The purpose of the interview was to examine each teacher’s beliefs about the teaching and learning of science. One overall belief emerged—that teachers believe the teaching and learning of science should be student-centered. There still exists gaps in the research between the teachers’ beliefs and the principles of science reform; however, this study suggests that there is a movement toward the suggested science education reform. Further research might suggest the same is true of the standards movement in mathematics education.

*Teachers’ Beliefs and Mathematics*

The research on teachers’ beliefs and mathematics suggests a focus on beliefs about mathematics and/or beliefs about mathematic teaching and learning. The focus of this section will address the relationship between teachers’ beliefs and their instructional practices. Although both elementary and secondary teachers have been studied, the majority of studies involved junior and senior high mathematics teachers (Thompson, 1992). Again, this reinforces the need for continued research with elementary mathematics teachers. There also exists research done with both pre- and in-service teachers. The following section will discuss the current research in the area of teacher beliefs and mathematics education.

*Teachers’ Conceptions About Mathematics*

Teachers vary in the way they view mathematics both in content and pedagogy. “Perceptions of the nature and role of mathematics held by our society have a major influence on the development of school mathematics curriculum, instruction, and research” (Dossey, 1992, p. 39). According to NCTM (2000), mathematics is a dynamic
process that engages students in purposeful problem-solving situations, where they are
required to use reasoning skills to apply information, discover, invent, and communicate
ideas, and ultimately reflect on learning. Traditionally, mathematics has been viewed as static.

Ernest (1988) defines mathematics in three different views: instrumentalist, Platonist,
and problem solving. The instrumentalist views mathematics as an accumulation of facts,
rules, and skills to be applied to determine an answer. Mathematics through this view is a
set of unrelated rules and facts to be learned by the student. The Platonist sees
mathematics as static but a unified body of knowledge. They believe mathematics is
discovered, not created. The problem-solving view determines that mathematics is
dynamic and will continue to be expanded in the field by individuals creating and
inventing solutions. The focus is on the process of inquiry instead of product-driven
answers. Mathematics is a cultural product and can continually be open to change. Other
researchers (Copes, 1982; Lerman, 1983; Skemp, 1978) discussed alternate views of the
nature of mathematics.

Lerman (1983) discussed two different conceptions of the nature of mathematics:
absolutist and fallibilist. The absolutist perspective believes all of mathematics is based
on universal and absolute foundations, meaning that knowledge is connected to the real
world, similar to the Platonist view. The fallibility perspective views mathematics as
developing though conjectures and proof and open to uncertainty. Ernest’s (1988)
problem-solving view is parallel to the fallibility perspective. In one study, Lerman
(1983) used an instrument to assess the perspectives of pre-service teachers. Of the four
pre-service teachers, he found two that were fallibilist and two absolutists. After
determining the pre-service teacher’s perspective, he asked them to share reactions from

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viewing a mathematics lesson. These reactions are concurrent with his finding from the assessed view of the nature of mathematics.

Based on Perry's (1970) work in epistemology, other researchers share models of mathematical conceptions. Copes (1982) discusses four types of conceptions: absolutism, multiplism, relativism, and dynamism. The four types of conceptions evolved throughout different historical periods. Absolutism views mathematics as a collection of facts that can be verified in the physical world. Multiplism sees different mathematic systems that can coexist within the world even though they might contradict each other. Relativism moves toward ideas of different mathematic systems coexisting and providing equally valid systems. Dynamism endorses one mathematic system within the context of relativism. This framework supports the idea that different teaching styles can communicate different conceptions.

Skemp (1978) also proposed that having two different conceptions of mathematics affects classroom instruction. These two ways of understanding that he refers to are: rational understanding and instrumental understanding. Viewing mathematics as a set of fixed plans is known as instrumental understanding. This means classroom instruction of mathematics consists of step-by-step procedures. In relational knowledge of mathematics, the individual acquires conceptual understanding of mathematics by constructing several methods for problem solving. Skemp (1978) believed that the difference that exists between these two ways of understanding mathematics is the root of many educational problems.
Table 2. Teachers’ Conceptions About Mathematics as it Relates to World Views

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<td>Ernest (1988)</td>
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<td>Copes (1982)</td>
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<td>Skemp (1978)</td>
<td>Instrumental Understanding Perspective</td>
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The framework used in this study relates to the above models of conceptions of mathematics (Table 2). Schraw and Olafson (2002) worldview model consisted of three positions: realist, contextualist, and relativist. The realist views mathematics like Ernest’s instrumentalist, Copes’s absolutist, and Skemp’s rational understanding perspective. All of these positions view mathematics as a set of factual procedures that are unrelated. The contextualist worldview is similar to Ernest’s Platonist, Lerman’s absolutist, Skemp’s instrumental understanding perspective and both Copes’s multiplist and relativist. Here, knowledge is constructed and connected to the real world. The relativist worldview has connections to Ernest’s problem solving, Lerman’s fallibilist, Copes’s dynamism, and Skemp’s instrumental understanding perspective. In this context, knowledge of mathematics is believed to be dynamic and can be continually open to change. This means knowledge is contextual and based on specific applications. Based on a teacher’s conceptions of mathematics, there are implications for instructional practices. The next
section of this review examines the literature on teacher beliefs of mathematics and instructional mathematical practices.

*Teachers' Beliefs of Mathematics and Instructional Practice*

Among the current researchers, there is no agreement about how teachers' beliefs about mathematics affect instructional practices. Shirk (1973) examined the conceptual frameworks of four pre-service elementary teachers and compared it to the teachers' behavior during small group mathematics instruction. Both the teachers' conceptions of mathematics teaching and the teachers' conceptions of their role as teacher comprised the conceptual framework. The findings reported similar elements of teachers' conceptions; however, different teaching behaviors were found in each case.

Some studies find that teacher beliefs and mathematical practice are consistent. Thompson (1984) conducted case studies of three junior high school teachers to investigate their conceptions of mathematics and how this impacted mathematics teacher. Findings suggest that teachers' beliefs about mathematics did impact their instructional practice. One case study teacher, Lynn, viewed mathematics as instrumentalist, hence taught in a traditional step-by-step procedural fashion. Conversely, Jeanne understood mathematics like a Platonist, where her instruction focused on student development of conceptual understanding and the logic of mathematical procedures. On the other hand, Kay endorsed a problem-solving view of mathematics and taught students to engage in the generative processes of mathematics.

Other studies address inconsistencies involving mathematics instruction and beliefs. Kesler (1985) studied four senior high school mathematics teachers and found some inconsistencies between teachers' conceptions of mathematics and teaching practice. Two
of the four teachers taught in a manner that was reflective of their espoused conception of mathematics; however, two of the other teachers taught in a way that was inconsistent with their conception of mathematics. Thompson (1992) cautions future researchers to not only analyze the teachers’ espoused beliefs, but also to “include an examination of the instructional setting, the practices characteristics of that teacher, and the relationship between the teacher’s professed views and actual practice” (p. 134).

Shaw (1989) built on the work of Skemp by conducting a study to compare three middle school teachers’ ideal and actual beliefs about understanding. Ideal beliefs are how the teachers would prefer to teach in order for students to learn; whereas, actual beliefs are how the teacher actually teaches based on the contextual factors of the classroom. The data sources included daily observations, daily interviews, and three questionnaires. The observation period lasted three weeks and the teachers were able to respond to the analysis of their beliefs. Skemp’s model (1978) of relational and instrumental understanding was used to demonstrate how these teachers were teaching for concept development, how they were teaching for a procedural development, and how their students were learning mathematics. The findings revealed that teachers may hold idea clusters of beliefs about understanding very differently from their actual clusters of beliefs. There were several contextual factors that attributed to the way teachers delineated from their idea beliefs, such as how they learned mathematics, how they had been teaching mathematics, students’ backgrounds and goals for learning mathematics, standardized tests, administrative demands, textbooks, and time.

More recently, Raymond (1997) investigated the relationship between a beginning elementary school teacher’s beliefs and mathematics teaching practices. Data sources were collected through audio-taped interviews, observation, document analysis, and a
beliefs survey over a ten-month period. Findings indicated that the teacher’s beliefs and practice were not always consistent. Raymond found that the teacher’s practice was more closely related to her (one female teacher studied) beliefs about mathematics content rather than pedagogy. The beginning elementary teacher’s mathematical content knowledge was influenced by her own experience as a student; however, her beliefs about pedagogy were influenced by her own teaching practice. The study was unable to determine the extent to which the teacher’s preparation program influenced her beliefs and/or practice.

Benken and Wilson (1998) studied one pre-service secondary teacher’s beliefs about the nature of mathematics. The research discussed how these beliefs were related to the pre-service teachers’ practice. Data were collected through interviews and observations through the last year of her undergraduate program. The findings indicated that the pre-service teacher emphasized the importance of cooperative exploration by students to understand connections among mathematical concepts. However, due to her beliefs about the importance of implementing mathematical procedures, she did not demonstrate exploratory, student-centered learning activities during student teaching.

Existing classroom teachers have also been studied to determine changes in teacher’s beliefs. Breyfogle and Van Zoest (1998) investigated four veteran mathematics teachers’ beliefs about mathematics and implementation of mathematics reform based on NCTM’s *Professional Standards for Teaching Mathematics* (1991). Data sources spanned over four years and included an essay application to the program, reflective writing assignments, annual extensive reflective final projects, journal entries, pre-test and post-test project beliefs survey, classroom observation, and interviews. Findings reported that two teachers whose practice most reflected that of reform efforts described their change
as personal while the other teachers talked about changes in implementation of reform in regards to the need for others to change. While this study is important to consider when examining standards-based mathematics education, the next study addresses factors that prohibit teacher's instruction.

By examining teachers' beliefs, researchers have sought to determine the impact it has on student achievement. Muijs and Reynolds (2002) studied the relationship between teachers' behaviors, teachers' beliefs, teachers' self-efficacy, and teacher subject knowledge with students' achievement in mathematics. Data sources included achievement tests, classroom observation, and questionnaires. The subjects were 103 primary school teachers and 2,148 students in the United Kingdom. The data supported the hypothesis that all the above factors would have a direct or indirect affect. Structural equation modeling was used to test the hypothesis. This is a comprehensive approach to testing hypotheses about relations between variables. The factors most closely related to student achievement such as teacher behaviors had the strongest direct effect.

Mapolelo (2003) conducted case studies of changes of beliefs of two in-service primary school teachers as they progressed through a four-year degree program. The study's purpose was to identify how these teachers' views about mathematics and teaching practice evolved during the three years prior to their internship assignment. The study documented whether changes in teachers' beliefs occurred concurrently as did those of instructional practice. Mapolelo wanted to determine what influenced the teachers to commit to change. Data sources included class observations, interviews, reviews of the lesson notes, field notes, and internship books. Findings indicated that only one in-service teacher changed some of his beliefs about mathematics teaching. This change was due to a shift in perception of the teacher as an authority to that of a student-
centered classroom. The other in-service teacher continued to view the teacher as an authority who gave procedural instructions. However, both participants' beliefs on how to learn mathematics changed from emphasizing algorithms to understanding concepts. Existing classroom teachers have also been studied to determine changes in teachers' beliefs.

Mathematics Education

The publication of the *Curriculum and Evaluation Standards of School Mathematics* (National Council of Teachers of Mathematics, 1989) promoted the reform of mathematics education to help all children learn with greater understanding. Active learning is the basis for the standards for both the National Association of the Education of Young Children (NAEYC) and the NCTM. It has been found in the United States that most mathematics teachers focus on procedural knowledge, which includes formulas, repetition, and set procedures for determining an answer for problem solving. Trends in International Mathematics and Science Study (TIMSS) research indicates that active learning and problem solving are more acceptable than rote memorization. TIMSS found three areas of focus for mathematics based on the responses from teachers in the United States: 1) hands-on, real world mathematics, 2) cooperative learning, and 3) a focus on thinking. Despite an understanding of the NCTM standards, it is not evident in the classroom practice of these teachers. Giest (2001) suggested the following reasons why this is the case. First, teachers are not using standards to teach, but instead are using textbooks that are not designed for each states' curricular guidelines. Second, teachers have an extensive amount of curriculum to cover within a limited time frame. By using teacher directive approaches and passive learning, these teachers are able to cover the
curriculum, but are unable to implement standards. The primary concern of teachers appears to be covering the material outlined in the textbook.

These issues create the growing debate among educators as to how to best approach decisions made about curriculum, pedagogy, and assessments. The scope of this study will examine teacher beliefs in mathematics through the worldview of the realist, contextualist, and relativist. The realist teacher endorses traditional approaches to mathematics that consists of accumulation of facts, rules, and skills to be applied to determine an answer. The contextualist emphasis curriculum, pedagogy, and assessments that are aligned with the NCTM standards. The relativist view focuses on each individual child and does not adhere to a particular curriculum. The following section of the review will address studies that examine a traditional approach to mathematics versus a standards-based approach.

*Traditional Mathematics*

One such traditional mathematics program called Saxon Math provides incremental instruction, continual practice, and cumulative assessments. Incremental instruction means using small, easily digestible chunks of information to teach students (Hirsch, 1996). The goal of Saxon Math is to use incremental instruction throughout an academic year therefore, distributing instruction (Dempster & Farris, 1990). Practice of an increment is distributed continually across each grade level. This ensures that concepts are committed to long-term memory and that students achieve automaticity of basic math skills. Students who are taught with a mathematics curriculum that uses continual practice and review have shown greater skill acquisition and math achievement (Mayfield & Chase, 2002; Ornstein, 1990). Dempster (1991) found that frequent and cumulative testing instead of seldom testing or testing that relates only to content covered since the
last test promotes higher levels of achievement in student learning. The foundation of Saxon Math is the theory-based distributed approach to mathematics instruction, practice, and assessment. According to various studies, Saxon Math has significantly increased student achievement in comparison to other textbook programs (Foundational Research and Program Efficacy Studies, 2004).

The following research is shared to demonstrate the effects of using a procedural approach to mathematics instruction. Hasen and Green's (2000) quasi-experimental study lent support to the idea that Saxon Math helped increase student achievement. The study was a comparison of two groups of 4th-grade students in Georgia; one using Saxon Math and the other one using the Macmillian text, Mathematics in Action. Scores from the prior years Iowa Test of Basic Skills (ITBS) were used as the pre-test while ITBS from the end of the year were used as the post-test. Findings demonstrated that the Saxon group had greater gains in mathematics achievement then those in the non-Saxon group. It is important to note that the difference between the groups’ post-test scores was not statistically significant. The Saxon group, however, began the study with lower achievement scores but ended the study with higher achievement scores when compared to the non-Saxon group.

The Department of Education’s “What Works Clearinghouse” (2004) executive summary report reviews the available evidence from research conducted since 1983 on the effectiveness of curriculum-based interventions for improving mathematics achievement for middle schools students. Two small studies were conducted focusing on 8th-grade students. In both studies, the students using Saxon Math scored higher on mathematics achievement tests than did students using another curriculum; however, the score was not statically significant. It is important to note that Saxon Math was compared
to an NCTM standards-based curriculum called the University of Chicago Mathematics Project. Connected Mathematics Project, which is a National Science Foundation funded standards-based curriculum project, was also evaluated. The results of the three quasi-experimental design studies were inconclusive. Johnson and Christensen (2004) defined a quasi-experimental research design as “an experimental research design that does not provide for full control of potential confounding variables” (p. 300). Findings indicated that there were two estimated sizable differences in mean scores for the intervention group (0.32 and 0.43 standard deviations), but the statistical significance of the estimate was based on a large sample of students and could not be determined. Estimates from the smaller study were not statistically significant. The third study found a negative effect, but again, was not statistically significant. The results of these studies do not provide conclusive evidence of the benefits of implementing a traditional approach to mathematics education.

Calvery, Bell, and Wheeler (1993) conducted a quasi-experimental study to examine the impact of Saxon Math on both 2nd- and 3rd-grade students in Batesville, Arkansas. Four classes of twenty-four students participated at each grade level; one class in each grade level used Saxon Math, while the other three classes used a non-Saxon math program. To establish a student baseline and measure progress throughout the year, the Stanford Achievement Test 9 (SAT 9) was administered as a pre- and post-test. Three dimensions—concept of numbers, mathematic computations, and mathematics application—were used to determine a total battery score for mathematics. Findings indicated that students in both grades that received Saxon instruction made significantly greater gains than did students instructed in the non-Saxon groups. Saxon instruction groups for both grades contained students who started as lower achievers than their
counterparts in the non-Saxon groups, however, the Saxon students caught up by the end of the study. This study suggests that the Saxon method of instruction could improve math achievement for underachieving students.

In 1992-1993, a study of Oklahoma City Public Schools done by Nguyen and Elam (1993) found more support for Saxon Math. Participants included students in fifty-six classrooms, kindergarten through 5th grade, who received Saxon Math instruction. The comparison group consisted of students, kindergarten through 5th grade, in more than 300 classrooms where instruction was from a Scott Foresman math program. Analysis of the Iowa Test of Basic Skills (ITBS) scores revealed that the Saxon group scored higher than the comparison group on all of the five ITBS math components: composite, total mathematics, problem solving, mathematics concepts, and mathematics computation. The differences in score were found to be statistically significant.

The following year, Nguyen (1994) again studied the effectiveness of Saxon Math in Oklahoma City Public Schools. Five schools that implemented Saxon Math were compared to all 1993-1994 student ITSB scores. The Saxon schools, again, scored higher on all five math components, but significantly higher in composite, total mathematics, mathematics concepts, and problem solving.

Other studies have confirmed the same results for Oklahoma City Public Schools. Crawford and Raia (1986) conducted a quasi-experimental study with the Oklahoma City Public Schools to examine the achievement of students using the Saxon Algebra ½ textbook and compared it to students using a Scott Foresman textbook. During the 1984-1985 school year, a total of 331 8th-grade students, seventy-two students in the Saxon group and 259 students in the Scott Foresman group were participants for the study. The pre-test scores for the participants came from the California Achievement Test (CAT) the
prior year. By the spring of 1985, the CAT was administered as the post-test. Findings showed that the Saxon group significantly outperformed the control group in total math score; however, in math concepts the difference was not statistically significant. In math computation, the Saxon group significantly outperformed the Scott Foresman group. Saxon Math studies have also been conducted in other areas.

Sixth-grade students from suburban Philadelphia schools participated in a quasi-experimental study done by Lafferty (1994). The study took place during the 1993-1994 school year and involved a total of 454 students. One group of students used the Saxon Math 6/5 textbook while the other group used an Addison-Wesley 6th-grade textbook. The pre- and post-test consisted of the Metropolitan Achievement Test (MAT). In addition to the MAT, a mathematics-anxiety scale was also administered at both the beginning and the end of the study. Findings showed that the Saxon group scored significantly higher overall on the MAT than the comparison group. On the mathematics computations subtest, the mathematics concepts, and problem solving subtest, the Saxon group scored significantly higher than the Addison-Wesley group. The Addison-Wesley group demonstrated higher math-anxiety levels than that of the Saxon group. Studies of other traditional programs showed improvements in student achievement.

Alsup and Springler (2003) compared a traditional mathematics curriculum with a reform mathematics curriculum and a combination of both curricula in an 8th-grade classroom. Data consisted of three years of the Stanford Achievement Test (SAT 9) and included SAT total scores, SAT problem-solving scores, and SAT procedure scores. Findings reported no significant differences found in comparing SAT total scores and SAT problem-solving scores. The students in the traditional curriculum group show a significant improvement in SAT procedural scores in comparison to the reform
mathematics curriculum and the combination of both curricula.

The research connected to Saxon Math and other traditional mathematics programs was discussed to demonstrate the effects of using a procedural approach to mathematics instruction. This approach to mathematics is supported by the realistic beliefs about curriculum, pedagogy, and assessment. The studies shared in this section produced findings about the success of traditional mathematics teaching. Research conducted in traditional mathematics programs have been driven by quantitative studies. The following section will discuss standards-based mathematics instruction.

Standards-Based Mathematics

NCTM (1989) has developed and disseminated standards for curriculum, teaching, and assessments. The standards have guided decision making to improve mathematics instruction in the United States. NCTM has six principles for school mathematics that address overarching themes: equity, curriculum, teaching, learning, assessment, and technology. For the purpose of this study, four of the six principles will be examined: curriculum, teaching, learning, and assessment. The curriculum principle states that curriculum is not just a collection of activities, but that it must be connected, attentive to important mathematics, and communicated across the grades. Teachers are required to understand what knowledge the students have and what they need to learn. The teaching principle requires teachers to challenge and support student learning. The learning principle states that students must understanding mathematics. This is done through actively building new knowledge from experiences and prior knowledge. The assessments are used to support the learning of mathematics. The use of multiple assessments is promoted: open-ended questions, constructed-response tasks, selected response items, performance tasks, observations, conversations, journals, and portfolios.
These principles address how curriculum, pedagogy, and assessment should be implemented by teachers (NCTM, 2000). The following section will address the literature connected to standards-based mathematics.

Riordan and Noyce (2001) examined the impact of two standards-based mathematics curricula on student achievement in Massachusetts. A quasi-experimental study using match comparison groups was used to investigate student achievement in one elementary and one middle school. Statewide standardized test scores of 4th-grade students using Everyday Mathematics and 8th-grade students using Connected Mathematics were compared to demographically similar students using traditional curricula. Findings indicate that students in schools that used standards-based curriculum performed significantly better on the statewide mathematics test than those in the traditional group.

Insook (2004) investigated the effectiveness of two different theoretical models, constructivism (standards-based instruction) and traditionalism. The study examines 3rd-grade students' academic achievement in establishing mathematical connections in learning multiplication basic facts. In the St. Louis area Public School District, four 3rd-grade classes were grouped into two sections containing two classes in each section. Students were taught using a constructivist approach in the first section of classes while students were taught using a traditional approach in the second section of classes. Tests were administered as both pre- and post-tests and included the Stanford Diagnostic Mathematics Test (4th edition), Key-Math (Revised), A Diagnostic Inventory of Essential Mathematics, and a Research-Made Multiplication Survey. The test scores were analyzed by repeated measures Analysis of Variance (ANOVA), with a probability level of less than 0.05. Findings on the three tests showed that students from both approaches improved their multiplication skills, in addition to understanding multiplication concepts.
that involves basic facts 0 to 5. There were no statistical differences between the two
groups of students with respect to their achievement of multiplication concepts and skills.
Insook (2004) does remark that concrete materials were used for only ten of the
constructivist lessons and students’ achievement scores increased, which may indicate
that the use of manipulative materials throughout the school year could produce greater
gains. This study supports the use of standards-based materials and curriculum in the
classroom environment.

Hannafin (2004) studied the achievement differences in structured versus
unstructured instructional geometry programs. The participants were 151 7th-grade
students who were asked to work through fourteen instructional activities in The
Geometer Sketchpad (a geometry software program) along with completing a geometry
tutorial that followed state geometry standards. Findings indicated that low-ability
students scored higher in the less structured program, however the high- and medium-
ability students scored better in the structured program. The high- and medium-ability
students scored better than the low-ability students by a greater gain on the difficult
items, as opposed to the easy items. Hannafin (2004) stated, “Although their overall
performance was poor in both programs, that low-ability learners performed relatively
better in the less structured, less traditional mathematics activities is an encouraging
finding for mathematics educations and designers of open-ended learning environments”
(p. 19). The standards-based mathematics movement promotes open-ended learning
environments. This study supports teaching mathematics from a standards-based
approach to instruction.

Implementation of standards-based mathematics can pose a problem for teachers.
McCaffrey, Hamilton, Stecher, Klein, Bugliari, and Robyn (2001) investigated the degree
to which teachers’ use of instructional practices aligned with the standards is related to
student achievement. The data sources included student achievement test scores, teacher
questionnaire responses, and student demographics. Student achievement data was
comprised of the Stanford Achievement Test Series, Ninth Edition (Stanford 9) Form T
mathematics test. Data was collected from 10th-grade students during the 1997-1998
school year. Some of the students received traditional algebra and geometry instruction
while others enrolled in integrated math courses that reflected the mathematic reform.
Findings showed that standards-based practices were positively related to achievement
for students in the integrated math course; however, these reform practices were found to
be unrelated to achievement in the traditional algebra and geometry classes. These results
suggest that in order to affect student achievement, changes need to happen concurrently
with both mathematics curriculum and instructional practices.

Carol (1996) examined 5th-grade students who had been in a reform-based
mathematics curriculum since kindergarten and followed the University of Chicago
School Mathematics Project elementary program, Everyday Mathematics (UCSMP). She
administered a twenty-five-item whole class test on mental computation problems to four
5th-grade classes. Findings indicated that students who experienced reform-based
mathematics showed a strong ability to calculate mentally. The UCSMP group did better
than the baseline group on all multiplication and division problems involving powers of
ten. On both the story problems and addition problems that required chaining from left to
right, the UCSMP students outperformed the baseline group. This study showed that
students who are taught using a standards-based mathematics program are much more
capable of learning and using mental computation than those in traditional curricula
classrooms.
Carroll (1997) furthered her research by examining the test scores of 3rd-grade students using a reform curriculum on the mathematics portion of the Illinois Goal Assessment Program (IGAP). The students in the study had been using the University of Chicago School Mathematics Project (UCSMP). Students from twenty-six schools were tested to determine the effects of the reform mathematic program. Students in fourteen of the participating school reported having had UCSMP for mathematics instruction since kindergarten, while the remaining twelve schools adopted the program within the last year or two. Findings revealed that the mathematical understanding constructed by students in a standards-based program does transfer to traditional measures. Students who had been in classrooms that used UCSMP scored well in all mathematical areas and only 2% failed to meet state goals. The students who had used UCSMP since kindergarten outscored students who had only been using the curriculum more recently. These results indicate a positive longitudinal effect of a standards-based mathematics curriculum.

Mayer (1998) conducted a study to examine whether middle and high school algebra students taught using the NCTM standards-based mathematics approach performed differently on three standardized algebra assessments than students who received traditional instruction. The data was collected from one of the largest school districts and included ninety-four teachers, 2,369 students, and forty schools. Findings reveal that middle school students who were taught using the NCTM approach had a higher growth rate than the students who receive little to no reform-based teaching. The study demonstrated that students with higher ability levels benefited more from the NCTM approach. Low-achieving high school students were not helped or hindered by the standards-based mathematics instruction. “If, as other studies indicate, the new standards help students on more novel tests, the findings that students benefit or at least are not hurt...
on traditional tests strengthen the case for implementing the NCTM reforms” (Mayer, 1998, p. 53).

Boaler (1998) conducted a three-year case study of two schools with different approaches to teaching; one school used open-ended activities while the other one used a traditional textbook approach. Data sources included observations, questionnaires, interviews, and quantitative assessments. Findings indicated that students who received a traditional approach to instruction developed a procedural knowledge that was not useful in unfamiliar situations. On the other hand, the students who received instruction in an open-ended, project-based environment developed a conceptual understanding of mathematics and were able to apply that meaning through different assessments and situations. This study suggests that reform mathematics in the classroom provides students with more of the necessary skills needed to succeed in mathematics in the school and real world settings.

The research connected to standards-based mathematics programs was discussed to demonstrate the effects of using a constructivist approach to mathematics instruction. This approach to mathematics is supported by both the contextualist and relativist beliefs about curriculum, pedagogy, and assessment. The contextualist teacher endorses constructivist practices in the classroom through a standards-based approach to teaching mathematics. Although the relativist teacher supports students constructing knowledge, they are in opposition to following a standards-based curriculum for all students.

This review first discussed the historical development of epistemology and world views. This research informs the reader as to how world views relate to the field of mathematics education. Next, teachers’ beliefs about mathematics and teaching and learning were examined through a number of studies. The final section of the review
addressed studies that involved two opposing views in mathematics education: traditional and standards-based mathematics. The traditional approach to mathematics instruction concentrates on rote memorization of mathematics facts and involves teacher directed instruction; whereas, the standard-based movement focuses on the process of learning mathematics through hands-on experiences and incorporates student-centered instruction. This study seeks to understand the relationship between teachers’ beliefs in mathematics and their instructional practices.
CHAPTER 3

METHODOLOGY

The methods and procedures used in this study are detailed in this chapter. This chapter was organized into four sections: 1) research design, 2) settings and participants, 3) instrumentation and procedures, and 4) treatment of data. Human subjects' protocol procedures have been approved by the university and school district in which the study was conducted.

Research Design

In order to understand teachers’ approaches to classroom practice, this study explored the relationship between teachers’ beliefs about mathematics and their mathematics instruction. The personal epistemology of the elementary mathematics teachers used in this study was documented and analyzed to provide evidence of the connection between teacher beliefs and practice in an elementary school setting. This study examined the relationship between teachers’ beliefs in mathematics and their instructional practices.

The design of this study was a qualitative case study. Creswell (1998) defined a case study as, “An exploration of a bounded system or a case over time through detailed, in-depth data collection involving multiple sources of information rich in context” (p. 61). This study embodied the case study paradigm because data was collected through three different qualitative means: interviews, observations, and documentation. Case study was
the most appropriate methodology for this study because the case was bounded by the grade level examined—the 3rd grade. The individuals chosen for the study defined the case being studied. The participants' perspective was shared through interviews, observations, documents, and audio-visual materials. The in-depth focus of this study allowed the researcher to collect data over a period of time to examine different teachers’ perspectives and implementation of mathematics instruction, making case study the most suitable methodology for this study. Case study methodology was prevalent in other related research regarding teachers’ beliefs in mathematics.

Setting and Participants

Thompson (1984) conducted case studies of three junior high school teachers to investigate their conceptions of mathematics and how this impacted mathematics teaching. Findings suggest that teachers’ beliefs about mathematics did impact their instructional practice. Shaw (1989) conducted a study to compare three middle school teachers’ ideals and actual beliefs about understanding. Findings indicate inconsistencies between teachers’ beliefs and actual teaching practice. Both of these studies focused on a small number of intermediate teachers. Research has been conducted with pre-service elementary mathematics teachers but has been limited due to the even smaller number of case study individuals. Benken and Wilson (1998) examined one pre-service teacher while more recently Mapoelo (2003) selected two pre-service teachers to research. The need for in-depth multiple case study research involving elementary mathematics teachers is crucial.

Furthermore, Ball, Lubienski, and Mewborn (2001) believe that teachers’ difficulties supporting and extending their students’ thinking may be due in part to their
lack of knowledge. They suggested that teaching requires pedagogically useful mathematical understanding. They concluded that in order to improve mathematics teaching, researchers needed to shift their focus from studying teachers to studying core activities of teaching so they can better understand the knowledge that teachers use when working with students. This provides support for studies involving understanding teachers’ beliefs about curriculum, pedagogy, and assessment. This study not only focused on the teacher, but also examined the strategies employed to teach mathematics education.

This study was a case study of three elementary school teachers from different schools in the same school district located in the southwestern United States. These 3rd-grade teachers were identified based on their willingness to participate in research concerning mathematics education. This was a form of purposeful sampling in which participants were selected based on the researcher’s special knowledge about a group (Berg, 2002). Prior to this study, data collected from previous research projects informed the researcher as to which teachers would be candidates for participant selection. Due to the in-depth, descriptive nature of this study, participants were selected based on rich data provided from previous research. This prior data provided the researcher with cause to follow-up with a study concerning teacher beliefs. The teachers selected espoused particular beliefs about mathematics and teaching; however, inconsistencies needed to be examined in a more focused study. Once an initial list of teachers was made, the researcher contacted the teachers and principals through email and requested permissions to visit classrooms. The pseudonyms Katie, Jenna, and Sara were used to identify the individuals in the three cases. Teachers were asked to sign the informed consent form (Appendix A), and the principals of the participating schools provide a facility
authorization letter (Appendix B). The schools demographic profiles were included to account for differences in the selected elementary schools.


<table>
<thead>
<tr>
<th>Demographic Profile</th>
<th>Case One School</th>
<th>Case Two School</th>
<th>Case Three School</th>
<th>District</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Enrollment</td>
<td>725</td>
<td>1,018</td>
<td>618</td>
<td>267,858</td>
</tr>
<tr>
<td>American Indian/Alaskan Native</td>
<td>0.7%</td>
<td>0.7%</td>
<td>1%</td>
<td>0.9%</td>
</tr>
<tr>
<td>Asian/Pacific Islander</td>
<td>5.4%</td>
<td>5.4%</td>
<td>2.1%</td>
<td>7.9%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>24.8%</td>
<td>80.2%</td>
<td>35.4%</td>
<td>33.4%</td>
</tr>
<tr>
<td>Black</td>
<td>16.1%</td>
<td>5.5%</td>
<td>0.6%</td>
<td>14%</td>
</tr>
<tr>
<td>White</td>
<td>53%</td>
<td>8.3%</td>
<td>60.8%</td>
<td>43.9%</td>
</tr>
<tr>
<td>Students with Disabilities</td>
<td>9.7%</td>
<td>5%</td>
<td>9.5%</td>
<td>10.1%</td>
</tr>
<tr>
<td>Students with Limited English</td>
<td>10.3%</td>
<td>68.5%</td>
<td>25.2%</td>
<td>19.5%</td>
</tr>
<tr>
<td>Students qualifying for Free/Reduced Lunch</td>
<td>37.7%</td>
<td>100%</td>
<td>53.7%</td>
<td>35.6%</td>
</tr>
</tbody>
</table>

School Demographics

Teachers in the study were employed in a large metropolitan school district in the southwestern United States. The student population of the district represents very diverse ethnic backgrounds with that diversity reflected in many of the elementary schools. Case one and three schools most commonly represent that of the district in many of the above listed categories. Case two school was an “at risk” school based on the number of students eligible for free or reduced-cost lunches and the percentage of English language learners. Katie taught at the case one school while Sara taught at the case three school, both of which represent a predominantly white student population. Jenna who taught at the case two school was in an environment with a high population of Hispanic students. In order to better understand the case study teachers, a detailed description of the
background and experience of each teacher was provided.

Case One: Katie

Katie obtained her bachelor's degree in teacher education and went on to receive a master's degree in mathematics education. In addition to these degrees, she has thirty-two credit hours beyond her master's degree in related coursework. Katie has been teaching for twelve years, eight of which were at the elementary school where she is currently teaching. She has taught 1st, 2nd, and 3rd grades; however, nine years were spent in 3rd grade. Katie remembers her mathematics education focused on worksheets and was driven by a traditional textbook. Through teaching mathematics, Katie learned different techniques of teaching. She enjoys thinking about numbers and making estimates about answers in a problem-solving situation. For example, Katie has trouble remembering $12 \times 11$, but she can automatically recall $12 \times 12 = 144$. To determine the answer to $12 \times 11$, she subtracts one group of 12 from 144 to determine the answer 132. She learned to think this way from participating in a professional development grant funded by the National Science Foundation (NSF), along with pursuing her masters. Currently, she works with another school in the capacity of a teacher leader who contributes ideas about how to use different strategies in mathematics instruction.

Case Two: Jenna

Jenna stated that working with children is what keeps her teaching because it gives her a sense of accomplishment. The excitement in teaching for Jenna is when the students discover a new strategy or learn a new skill in mathematics. She has bachelor's degree in elementary education and a master's degree in literacy education. Professional development courses offered by the Mathematics and Science Enhancement (MASE) grant funded by NSF have enabled Jenna to gain knowledge about teaching mathematics.
Jenna has taught for a total of eight years, one year in 1st grade and the last seven in 3rd grade. Jenna claims that she has developed her teaching through on-the-job training, in addition to the professional development provide for her. She stated that students will use mathematics throughout their lives and elementary school is especially important as it provides a foundation for conceptual development.

Case Three: Sara

Sara began her educational career as a librarian for ten years and then became a support staff assistant librarian for five years in the school district where she currently works. When the school she was working for lost the head librarian, they hired Sara to take the position as a long-term substitute for the year. It was during this time that Sara decided to go back to school and obtain a teaching degree. She currently has a bachelor’s degree in elementary education, with a minor in early childhood and reading, in addition to a master’s degree in education. Through the MASE professional development, Sara claimed it helped her think about teaching, how students were thinking, and what she wanted the students to be learning in mathematics. Sara has been a classroom teacher for ten years in 3rd grade, exclusively. She admits that literacy is her first priority in the classroom because it impacts all of the other subjects. For students to be successful as a problem solver in mathematics, they must first know how to read. Sara does go on to say that mathematics is important too because it prepares students for real life. In the 3rd grade, she believes mathematics is especially important because students use their prior knowledge to build higher mathematics concepts.
Instrumentation and Procedures

Data Collection

The data chosen for this study is qualitative in nature because the information gained was conveyed through words. Qualitative data deals with direct quotations from participants through self-report that describe experiences, opinions, and/or feelings (Merriam, 1998). Data sources for this study consisted of interviews of teachers, observations of math lessons including videotaped lessons, and additional documentations of student work to understand how teachers approach student assessment. The use of multiple data sources enhanced the credibility of the study. Merriam (1998) notes that data collection in case study research consists of all three strategies of interviewing, observing, and analyzing documents. These three strategies were employed in the current study.

Interviewing

Using a personal interview format for this study was advantageous because the sample size was small, which allowed for open-ended questions (Fowler, 2002). The teachers selected for this study are 3rd-grade teachers at different elementary schools within the same school district. The personal interview allowed the participants to reflect upon practice in a detailed response. By using these semi-structured interviews, the researcher gained confidence in obtaining comparable data across subjects (Bogdan & Biklen, 2003). Because the researcher was the only one administering the interview, all questions from the teachers were answered with consistency. By conducting a personal interview, the researcher built rapport with these teachers, which resulted in more honest answers from the interviewees, thus making the survey valid. Personal interviews allow the researcher to gain rich narrative data from the teachers to analyze (Fowler, 2002).
A series of six in-depth interviews divided into two phases served as a major source of data collection. Phase I consisted of research done in the spring of 2005 that was used to inform this study. Based on data collected from this research, Phase II was designed for the current study. Phase I data is significant as it led the researcher to examine the data and research connected to teachers’ beliefs in mathematics education. Phase II of this study is dependent upon Phase I data to inform the in-depth nature of the study. Table 4 visually represents the interview sources for each of the two phases of data collection with a timeline.

Table 4. Interview Data Collection

<table>
<thead>
<tr>
<th>Phase I</th>
<th>Pre-Unit Interview (Appendix C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Structured Interviews</td>
<td>Mid-Unit Interview (Appendix D)</td>
</tr>
<tr>
<td>- Spring 2005</td>
<td>Post-Unit Interview (Appendix E)</td>
</tr>
<tr>
<td>- Video Observations</td>
<td></td>
</tr>
<tr>
<td>- Student Assessment Documentation</td>
<td></td>
</tr>
<tr>
<td>Phase II</td>
<td>Interview 1 – Vignettes (Appendix F)</td>
</tr>
<tr>
<td>- Open Ended Interviews</td>
<td>Interview 2 – Videotape Reflection</td>
</tr>
<tr>
<td>- Spring 2006</td>
<td>Interview 3 – Final Interview (Appendix G</td>
</tr>
<tr>
<td>- Observations</td>
<td>for both Interviews 2 and 3)</td>
</tr>
<tr>
<td>- Student Assessment Documentation</td>
<td></td>
</tr>
</tbody>
</table>

*Phase I*

Phase I data consisted of three structured interviews: 1) pre-unit interview, 2) mid-unit interview, and 3) post-unit interview. These interview questions were designed by a collaborative team in order to examine the effects of professional development on teachers of elementary mathematics. The unit of study was defined by the resources used by these teachers to address number system in the spring of 2005. All three of these
teachers utilized a book from the Investigations (TERC, 1998) series titled *Landmarks in the Hundreds* (Russell & Rubin, 1998) as major part of implementing instruction. All interviews were conducted to gain information regarding the teachers’ backgrounds, the units taught, and the teachers’ influences. Each interview in Phase I was structured and designed by a research team. The pre-unit interview (Appendix C) focused on the planning for the unit: goals, approaches to instruction, and assessment. The mid-unit interview (Appendix D) assessed the progress of the unit and addressed changes to the unit of instruction. After teaching the entire unit, a post-unit interview (Appendix E) was administered to examine the progress of the unit and adaptations that were made to instruction. The researcher reflected on this data to inform a more in-depth focus of interviews considering teachers’ beliefs in mathematics education for Phase II of the study.

*Phase II*

The purpose of Phase II was to deeply examine the relationship between teachers’ beliefs and practice in mathematics. Phase II consisted of more open-ended questions instead of predetermined questions that may limit the field of inquiry (Fontana & Frey, 1994). In this type of interviewing, the interviewer used prompts to stay oriented to the purpose of the study. Phase II of the study was conducted the following year in the spring of 2006. The same unit of study, number systems utilizing the Investigations book *Landmarks in Hundreds* (Russell & Rubin, 1998) was examined. The first interview consisted of asking the participants to read three vignettes (Schraw & Olafson, 2002) of teaching (realist, contextualist, and relativist) and asking questions to determine which worldview each teacher supported (Appendix F). The second interview required the teacher to reflect on her practice by showing video data collected from the previous year.
Current research (Berg & Smith, 1996; Sherin, 2000; Han & Sherin, 2004) used video data as a vehicle for investigating teaching practice and to better understand what teachers are doing in the classroom environment. The researcher selected a piece of video data that was taken from the spring of 2005 to examine with each individual teacher. The video clip was the same lesson for all three teachers, which allowed the case study participants to see how they taught. The goal of the interview was to deeply examine practice and challenge inconsistencies between prior interview data and practice. The third interview was conducted after observation of the unit in spring of 2006. All prior data sources were used to inform the open-ended format of this interview. Because of the nature of interviews two and three, the questions prompts were the same (Appendix G).

Beyond interview data, this study was comprised of observation data.

**Observations**

One of the major means of collecting data in a qualitative study is through conducting observations in a naturalistic setting (Bogdan & Biklen, 2003). In this study, observations of teachers’ mathematics lessons were conducted through observing a unit of mathematical study within their classrooms. This focus of the math unit was number system. Specific lessons were selected for analysis and comparison. Each teacher was observed during mathematics instruction for seventy minutes for the durations of the unit. During these observations, the researcher was a participant observer, watching the lesson from the back of the classroom as not to disrupt the lesson. The role of the researcher was to collect data that supported how the teachers approached mathematics instruction.

This study included focused observations that came from the unit of mathematical study implemented by the teachers, *Landmarks in the Hundreds* (Russell & Rubin, 1998). Phase I observation data consisted of observational data based on videotaped lessons.
One common lesson was selected to have each individual teacher view. Individual teachers watched a clip of their teaching from the spring of 2005. The lesson that was selected is titled “Finding Factors of 24, 36, and 48.” Through the interviews, teachers were asked to make connections between espoused world views and actual teaching practice. During Phase II, observations were made by the researcher to determine consistency in teaching the same unit a year later. This observational data was examined to provide support and/or inconsistencies between the teachers’ claimed worldview, as evidenced by the interview data and classroom practice. Focused observations came from the unit of mathematical study implemented by the teachers.

The field notes prepared from the observations and the interviews were the primary source of the data. Interviews were audio taped for the sole purpose of review by the researcher to confirm the accuracy of what was shared by the case study participants. The focus in this study was on the teacher, not the students, with particular interest in determining the extent to which what the teacher said in interviews about the instruction was consistent with actual implementation.

Documents

The use of interviews, observations, and documents such as student assessments were three ways to collect data in case study research. Merriam (1989) states, “One or two methods of data collection predominate; the other(s) play a supporting role in gaining an in-depth understanding of the case” (p. 137). By understanding how teachers’ assess students understanding of mathematics, this provided support and/or inconsistencies between teachers’ beliefs and practice. Through Phase I data collection, selected pieces of student assessment were shared with the researcher by the teacher to inform how the role of assessment was utilized to inform the teachers’ practice. In Phase II, documents were
selected by teachers once again to assess student learning and to illuminate future instruction. The document data collected consisted of lesson plans and assessments utilized by the teacher. No student work was examined. The selected document data was provided by the case study teachers and was used by the researcher to examine how assessment informs practice. The researcher analyzed the document data to determine how planning and assessments relate to world views.

Treatment of Data

Analyzing Data

Analysis refers to the systematic examination of something to determine its parts, the relationship between the parts, and the relationship of the parts to the whole (Spradley, 1980). Domain analysis was conducted through the interview, observation, and documentation data. The domain analysis allowed the researcher to determine which semantic relationships exist within the data. Spradley suggests six interrelated steps for domain analysis: 1) selecting a single semantic relationship, 2) preparing a domain analysis worksheet, 3) selecting a sample of fieldnote entries, 4) searching for possible cover terms and included terms that appropriately fit the semantic relationship, 5) repeating the search with other semantic relationships, and 6) making a list of all identified domains (1980, pp. 98-99). The researcher employed these procedures when analyzing the data.

The researcher investigated a part-whole relationship through the consideration of a set of semantic relationships. Through analysis of the data, the researcher formed a taxonomy. Based on information collected from the literature review of worldview, the researcher examined the teachers' espoused world views and which characteristic of
practice was evidenced from the teaching instruction implemented. Table 5 summarized the data collection and analysis for this study.

Table 5. Summary of Data Collection and Analysis

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Data Collection</th>
<th>Data Analysis</th>
</tr>
</thead>
</table>
| 1. What are teachers' beliefs about curriculum, pedagogy, and assessment? | Interview and documentation data | Domain analysis focused on strict inclusion.  
X is a kind of Y.  
X (beliefs about curriculum, pedagogy, and assessment) is a kind of Y (worldview: realist, contextualist, and relativist). |
| 2. What practices provide evidence of teachers' beliefs? | Observation and documentation data | Domain analysis focused on means-end.  
X is a way to do Y.  
X (characteristics of practice) is a way to do Y (espoused worldview). |

In order to answer Question 1 which defines teachers' beliefs about curriculum, pedagogy, and assessment, the researcher collected and analyzed interview and documentation data. Domain analysis focusing on strict inclusion (X is a kind of Y) was
conducted to determine how teachers' viewed curriculum, pedagogy, and assessment in the domain of mathematics (Spradley, 1980). This data contributed to defining the teachers' worldview.

Question 2, which defines how practice provides evidence of teachers' beliefs, required the researcher to examine observation and documentation data. Domain analysis focusing on a means-end (X is a way to do Y) was conducted (Spradley, 1980). The practice of each teacher either supports or rejects the worldview espoused. Descriptive language allowed the researcher to provide an in-depth analysis of what provided support for a specific practice. Characteristics of practice are based on those addressed in the review of literature.

For Question 3, which defines the relationship between teachers' beliefs in mathematics and their instructional practices, the researcher dissected interview, observation, and documentation data. Domain analysis focusing on rationale (X is a reason for doing or not doing Y) was conducted (Spradley, 1980). In order to answer this question, factors that influence practice were examined. Comparisons among the case study teacher were addressed. This data contributed to the implications for further research. Throughout the study, the researcher continually verified analysis of interview, observation, and documentation data with participants.
CHAPTER 4

FINDINGS OF THE STUDY

This study examines the relationship between teachers’ beliefs in mathematics and their instructional practice. Research was conducted in two phases. Phase I was conducted to determine the teachers’ background and initial espoused beliefs about mathematics and teaching. Phase II allowed the researcher to examine extensively the relationship between teachers’ beliefs and practices in mathematics. The presentation of results is divided into three sections: 1) teachers’ beliefs about curriculum, pedagogy and assessment, 2) practice that provides evidence of teacher beliefs, and 3) exploration of relationship between teachers’ beliefs in mathematics and their instructional practice.

Teachers’ Beliefs About Curriculum, Pedagogy, and Assessment

Schraw and Olafson (2002) described the comparison of beliefs across three epistemological world views: the realist, the contextualist and the relativist. The three areas of beliefs addressed in this study include: 1) beliefs about curriculum, 2) beliefs about pedagogy, and 3) beliefs about assessment. This study identifies which world view the case study teachers espoused within each area of belief. Analysis of the data included examining interview and documentation data. Spradley’s (1980) domain analysis focusing on strict inclusion of X (beliefs about curriculum) is a kind of Y (world view: 56
realist, contextualist, and/or relativist) was conducted to determine how teachers viewed curriculum, pedagogy, and assessment in mathematics instruction. The following table categorizes the beliefs about curriculum, pedagogy and assessment of the three case study teachers.

Table 6. Teachers' Beliefs About Curriculum, Pedagogy, and Assessment

<table>
<thead>
<tr>
<th>Case Study Teacher</th>
<th>Beliefs About Curriculum</th>
<th>Beliefs About Pedagogy</th>
<th>Beliefs About Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Katie</td>
<td>Contextualist and Realist</td>
<td>Contextualist and Realist</td>
<td>Contextualist and Realist</td>
</tr>
<tr>
<td>Jenna</td>
<td>Contextualist</td>
<td>Contextualist and Relativist</td>
<td>Realist and Contextualist</td>
</tr>
<tr>
<td>Sara</td>
<td>Realist and Contextualist</td>
<td>Realist and Contextualist</td>
<td>Realist and Contextualist</td>
</tr>
</tbody>
</table>

All three of the case study teachers utilized a book from an Investigations (TERC, 1998) series titled *Landmarks in the Hundreds* (Russell & Rubin, 1998) as a part of implementing mathematics instruction. This Investigations series as a curriculum resource that provides an inquiry-based learning environment for student learning. Through these lessons, students are asked to construct knowledge as a community of learners. The contextualist world view is concurrent with this approach to learning. The Investigations series is based on the NCTM standards as a vehicle for teaching mathematics. Because each teacher in the study uses this curriculum for teaching the unit on number sense, all of the case study individuals state using a contextualist curriculum. Teachers’ beliefs about curriculum were therefore consistent with the underlying curricular beliefs associated with the Investigations series.
Although all three teachers are expected to follow the same curriculum standards and use the same curriculum text as the main resource for implementing the unit of instruction, they espoused different pedagogical views. The realist perspective believes that learning is transferred in a programmatic fashion from teachers to students, while the contextualist world view supports the belief that students construct knowledge with other students in the classroom. Conversely, the relativist endorses discovery learning through student autonomy. Each teacher was given three vignettes of the different world views and asked questions about how they related to the world views. The following data analysis for all three case study individuals was taken from the Phase II vignette interview (Appendix F). The teachers were given three vignettes, one reflective of each world view, and were asked questions to gain insight into which perspectives they agreed and disagreed with and why.

Each of the case study teachers advocated using both realist and contextualist approaches to assessment in mathematics. The realist world view supports norm-referenced testing to evaluate students learning on mastery of skills. Computation tests done through a paper and pencil skill assessment are additional means of assessment for the realist teacher. Contextualist teachers are concerned with how a student uses different strategies for problem solving instead of solely focusing on product-driven results. The process of learning is examined to understand students' thinking. The following case study teachers discuss their beliefs about curriculum, pedagogy and assessments in mathematics education.

Case One: Katie

In addition to using the Investigations series, Katie supplements the unit by using worksheets and timed tests. When asked to identify with the world views during the
Phase II vignette interview, she discussed that she was partly a realist because, “knowledge doesn’t change much over time and it represents the accumulations of important truths and understanding, I just feel like, in math, it’s just there” (Vignette interview, p. 1). Here, the Investigations series curriculum served as the basis for Katie to teach skills to the students. She goes on to say, “I think in math there is some core body of knowledge that the kids need to know and it’s just important for them to know, it is factual, it’s truth that cannot be argued” (Vignette interview, p. 2). Katie stated she used worksheets and timed tests for practicing recall of math facts. Examination of Katie’s interview data lends support to the idea that she used both contextualist and realist curriculum resources.

When Katie was asked specifically which world view she most strongly agreed with and why, she responded:

In the contextualist, I like that students are encouraged to develop their own understanding in my classroom so that knowledge is personally useful to them. I mean it has to be something that they construct, on their own, so that it does make sense to them and they’re actually going to remember it. Students need to understand how to gather and evaluate evidence so they can distinguish good from poor arguments. I also like the last part, where it says, I try to structure my class so that students will pool their resources and come to the best understanding possible. I definitely try to have a lot of discussions, so that we can decide: Did your strategy really work? Was it the easiest strategy? Was there a better strategy? Why did it work for you, because kids learn from each other (Vignette interview, pp. 1-2).

Katie shared specific examples from her practice that supported her contextualist world views. For example, she believes in using everyday problems that are relatable for
students. She endorsed students working together and engaging in dialogue to justify their thinking. In one particular lesson, she talked about having students use cubes to find factors of 24. By using these cubes, students were constructing their own understanding of factors.

Although she provided support for the contextualist approach to learning mathematics, she also identifies with the realist world view:

There is a core body of knowledge in my classroom that each student must learn by the end of the year. The knowledge doesn’t change much over time and represents the accumulation of important truths and understanding. I just feel like, in math, it’s just there. Okay, well, in math things are just kind of cut and dry, I mean it’s kind of black and white a lot of times (Vignette interview, p. 1).

When asked about specific examples from her teaching that support the realist perspective, she talked about a lesson she conducted involving rounding:

Before Christmas we were going over rounding, and we were talking about the rounding rules, how you look to the right and if the number is 4 or less, then you round down and if it is 5 or more, you round up, okay, well there is me saying here is how it is, if somebody asked you how to round, here’s how you do it (Vignette interview, p. 4).

Katie also stated that it was important for students to have instant recall of multiplication facts, so timed tests are part of her daily instruction. These approaches to mathematics instruction support a realist world view. Katie could cite specific teaching examples to provide support of her endorsed world view. By examining the interview and documentation data, Katie demonstrates a combination of both contextualist and realist
mixed belief system. She is both a contextualist and realist in pedagogical approaches to
learning mathematics.

Katie says her assessments consist of informally evaluating students through
observations and through reviewing students' math notebooks. She does not allude to
formal criteria for observing student or for checking student work. She believes that the
assessment should align with her practice. In the classroom, Katie states that she has
students discuss ideas and use manipulatives to construct understanding, which means her
assessments should focus on how students are learning. Through observations, she can
check for understanding by questioning students. By viewing math notebooks, Katie can
view how students support their thinking and organize their work:

I'd like to actually watch them, and assess from that, because that's where their
thinking is, it's very concrete. That's they way I can see where, maybe they know part
of the concept and are a little confused on part of it, and by reading their writing, or
looking at their pictures, or talking with them, I can see where the breakdown with
their thinking might occur (Vignette interview, p. 5).

Katie supports a contextualist world view for assessment, but she also believes in
order to determine grades she must utilize assessments that are consistent with a realist
perspective. Katie recalls tasks such as worksheets, paper and pencil tasks and testing to
determine grades. Because the contextualist methods are too subjective in her opinion,
she believes the realist assessment can give her objective information that is easier to
transfer into a letter grade:
I was trying to teach both ways, but when it comes time for the test and they say rounding it to the nearest ten, they just need to know it. It is just cut and dry when you do it, so in that respect, I would say here are the rules, even though I did talk about it the other way (contextualist) (Vignette interview, p. 4).

One of the ways Katie discusses assessment from the realist perspective is by giving daily timed tests for multiplication. She wants the student to practice the multiplication facts for instant recall. Once a student passes the zero’s timed test, then they move to the one’s timed test and so on until they have mastered up to the twelves times tables. After the student passes all of the multiplication times tables, they move on to division timed tests in the same fashion. Katie is able to give specific examples that support her use of both contextualist and realist approaches to assessment. Overall, Katie uses both contextualist and realist forms of assessment.

Case Two: Jenna

Based on Jenna’s Phase II vignette interview, she discussed only using the Investigations series as a means of teaching her unit of instruction and does not use supplemental materials. She said the objectives that are taught in class come from the curriculum, meaning both state and national standards. Jenna explained that she implemented Landmarks in the Hundreds by doing every activity suggested in the text rather than implementing separate parts. She used the materials provided in the curriculum set and she did not deviate from the text. She believes that Investigations curriculum compliments state and national standards. Based on this evidence, Jenna espouses utilizing a contextualist curriculum.
Jenna supported a relativist and contextualist world view approach to learning mathematics. When asked what statements in the vignettes she most strongly identifies with, she said:

With the contextualist, I teach them some of these skills, but some they will have to learn by working with other students, or on their own. I believe that students will bring a unique and valuable perspective with them. For the relativist, what I know and believe shouldn’t really influence my students. My job is to create an environment where students can learn to think independently (Vignette interview, p. 2).

Jenna goes on to say that by students working together in a collaborative environment, they construct a variety of solutions to problems. She believes her role is to create a place for the student to learn where they feel comfortable to try new strategies and figure out which way works best for them. Because Jenna feels that she does not have all the answers and that things change all the time, this supports a relativist world view. A relativist teacher promotes individual learning, which means peers are important in the classroom only so they can model or promote self-regulation for other students (Schraw & Olafson, 2002). She goes on to remark that the students sometimes teach her different ways to problem solve. Throughout the interview, she espoused a blend of the world views however; ultimately Jenna specifically stated that she was more of a relativist in practice. Although she espouses a relativist perspective, she may have a misunderstanding of how it implemented in classroom practice. She states, “I thought this was interesting, knowledge comes and goes, and what the so-called experts consider the truth today will be viewed with suspicion tomorrow because it is true, in life” (Vignette interview, p. 4).
When asked to share specific examples from her practice that supported these world views, she talked about a ten-minute math activity from the Investigations series called “Guess My Rule.” The students are asked to create their own word problem and apply it to real word situations. This is reflective of a relativist world view because the students individually make problems based on their choice. Jenna discussed a lesson that involved students skip counting by smaller numbering in order to determine factors for larger numbers:

That’s what I’ve learned with Investigations that, if you just let them explore and investigate, they will usually take ownership of what they have learned initially and then be able to transfer it to the next concept, like with money in the Landmarks in the Hundreds book. They were able to take the money and then transfer it into the bigger numbers and understand the concept of factors (Vignette interview, p. 3).

Jenna did not specifically give an example that explained how money was used to develop an understanding of factors. She articulated her beliefs in regard to the world views of the contextualist and relativist, but struggled when asked for more specific examples from her teaching that supported these world views.

Jenna indicated that she struggles with assessments being too subjective when they are open-ended, especially due to that fact that her students have a language barrier. She uses observations and questioning as way to informally assess student learning. In addition, she uses open-ended tasks that allow students to explain their thinking; however, she does incorporate traditional worksheets for grading purposes. She expresses frustration with determining a grade through contextual approaches to assessment:
The assessment is two problems, and I have a hard time giving one of my kids a grade for a concept, for that activity on two problems because language is such a difficult thing for them to write down. So, it is better that I go around and asks them orally because some of them aren’t able to write down what they mean, especially in math (Vignette interview, p. 3)

The particular assessment she is making reference to asked the students to find the factors of 42 and explain how they know they have all the factors for this number. The second question asks the students to choose one of the factors listed by the student and explain how many of that factor it would take to make 42. Jenna values this task because she can examine how students are working on the concept of factors, but it is difficult to transfer into a letter grade. Because most of Jenna’s students are second language students, she believes it is difficult for them to convey their thinking in written form.

Another issue for Jenna is that her contextual practice does not match the end of the year state assessments given. The norm-referenced test emphasizes instant recall and does not focus on how knowledge is constructed. She uses recall forms of assessment (realist) to prepare students for these tests. During these assessments, the students are not allowed to use materials to help them explain the answers:

They were able to use play money coins to work out some of the math money problems (in the unit). Some of them had to use it because they didn’t understand that four quarters made a dollar. Some did not get it, or some got it from using the coins, but when the test comes they’re not going to be able to use that to help them solve those problems. The kids that did get it, I’m hoping will be able to transfer this concept to the assessment, but the ones that didn’t, are out of luck (Vignette interview, p. 4).
The use of observations, questioning, and open-ended tasks support contextualist methods of assessment. However, due to testing pressures resulting from school district pressures, Jenna also utilizes realist methods of assessment. She expresses concern that her teaching does not match all of the ways she assesses student learning.

Case Three: Sara

Sara believes in having a balanced math program that uses curriculum resources from a realist and contextualist world view. The majority of her mathematics teaching comes from Saxon (Larson, 2004), which most closely aligns with the realist worldview and focuses on basic recall and memorization of multiplication facts. The Saxon program is teacher-directed and the scripted lessons support a traditional teaching approach. In addition to Saxon, Sara supplements using the Investigation series because she says, “it teaches you how to use different strategies to get answers and to find different ways to do things and it does a lot of cooperative learning so that they can learn for each other” (Vignette interview, p. 1). Sara believes that Investigations does not cover all of the power standards and Saxon allows her to teach all the skills required for the third grade curriculum.

When asked which world view she most strongly identified with, Sara stated that she was primarily a realist with some beliefs from the contextualist world view. She described the realist practice in her classroom in the form of timed tests where the students are given a page of fifty multiplication problems and they have 2 ½ minutes to complete the test with 90% to 100% accuracy. If the student is successful, then they must also orally say the math fact to pass the specific number they are working on in the multiplication unit. The students are all working at their own pace through the multiplication timed tests. Sara also discussed using songs and drill games to reinforce
recall of basic multiplication facts, which is reflective of a realist world view. Although Sara supports a realist world view in teaching mathematics, she also speaks to the importance of a contextualist approach to learning. In the following excerpt, Sara describes this combination of beliefs:

You want them to have an understanding of what multiplication facts are and the process that is going on when you combine groups, but also you need them to memorize, so when they are doing higher math, when they are doing division, or when they are doing algebra, they don’t have to count on their fingers (Vignette interview, p. 2).

Consistent with a contextualist world view, Sara wants the students to use manipulatives to make groups and combine groups to arrive at a total. She uses the manipulatives to demonstrate how factors are concretely understood. One particular example she shared from the vignette interview involved students finding factors of 20 with cubes. The task was for students to make grouping with cubes for the number 20, draw a picture of the concrete representation, and write how they skip counted by the factor. When asked about which statements from the contextualist world view vignette Sara supported, she listed the following:

Students are encouraged to develop their own understanding in my classroom and knowledge is personally useful to them. However, the fact that students are expected to construct their own understanding doesn’t mean that all understandings are equally valid because some of them are going to have incorrect assumptions. Students need to understand how to gather and evaluate evidence so they can distinguish good from poor arguments. I can teach them some of these skills, but some they will have to learn by working with other students, or on their own. Definitely, because some
things they are going to learn better from a peer or from trial and error, and from experience (Vignette interview, p. 3).

Sara did not address how students work together to construct knowledge when asked about a specific example from her practice. She made reference to the use of manipulatives, but not how students learn from one another or how students defend their constructed answers. Based on the interview data, Sara explains clear examples of realist practice, but struggles to articulate the contextualist world view in teaching.

Sara discussed using informal assessment throughout the unit. From Investigations, she used the teacher checkpoint and embedded assessment activities. Teacher checkpoints offer a time to observe individual student, watch them at work and ask questions that illuminate how they are thinking. They also give the teacher a chance to pause in the teaching sequence and reflect on how the class is doing overall. The assessment activities embedded in each activity help the teacher examine specific pieces of student work, figure out what it means, and provide feedback. Many of the tasks require students to show what they did, write or talk about it, or do both. In terms of documenting student growth, *Investigations* suggests the teacher should document each student's work in journals, notebooks, or portfolios although; Sara did not reference any of these resources (Russell & Rubin, 1998).

These forms of assessment support a contextualist view. Contrary to what the other case study teachers remarked, Sara believes, "Investigations does a really good job with assessment" (Vignette interview, p. 5). Sara uses these assessments as a way to monitor student learning and to let her know if she needs to re-teach a concept to the students. Although Sara states she uses informal assessment, she does not describe how she conducts this in her classroom. According to the Investigations series, the teacher...
checkpoints are used to inform instruction, not to determine a grade. Sara states that she uses the teacher checkpoints in the book for a formal grade. She does not elaborate as to how these activities are used to form a grade. An example of a teacher checkpoint from *Landmarks in the Hundreds* is given below (Russell & Rubin, 1998, p. 12):

Use your cubes to show me one of the ways to count to either 36 or to 48. You should arrange your cubes in such a way that I can tell, just by looking at your cubes, what factors you chose and whether it makes 36 or 48.

After the students have arranged their cubes, the teacher circulates around the room to examine student's work. The teacher can also ask individual students how many groups they needed to make the total. The purpose of the assessment is to determine if the students understand that when they skip count by a number, there are accumulating groups of that number of objects. Another teacher checkpoint from the book poses two questions to the students: 1) how many 20's are in 100, and 2) how many 4's are in 100? The students are asked to find the answer and prove their solutions using coins, cubes, or 100's charts, then write or draw explanations of their solutions. Again, this is an example of how Sara assesses student learning. These specific examples, lend support for Sara's assertion that she uses contextualist method of assessment during the unit of instruction.

Sara used assessments from both the realist and contextualist perspective. Based on Sara's mid-unit interview, she claimed that 1/3 of her assessment comes from Investigations (contextualist), while 2/3 comes from Saxon (realist) to form grades. The performance assessment allows her to see how students learn, but Saxon provides her with assessment that can be given as a quiz to form a grade in a specific area of mathematics. Every five lessons, she gives her students a written quiz to check for

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understanding of a concept. When Sara was asked about which methods give her the most information about the learners in her classroom, this was her response:

Saxon was pretty easy to look at and say oh this student needs more work in measurement, or this student is not getting algebra or patterns and functions at all. I think that a lot of times, it’s better just to watch them work and see if they can actually complete a task, kind of a performance assessment. I think it needs to be balanced. I think it just gives you a different perspective and maybe you think that they understand it, but when you see them in action, you can see that they need more work on it, so both (Vignette interview, p. 3).

Sara struggles with a way to balance her approach to assessment. The realist approach gives her an easy way to determine grades; however, she believes that a contextualist view of assessment allows her to examine how students understand a specific concept. Because most of her teaching reflects a realist world view, it seems logical that this would be validated by using realist approaches to assessment.

Conclusion

All three case study individual espoused using a contextualist curriculum in the classroom. This involves utilizing an Investigations (TERC, 1998) textbook called *Landmarks in the Hundreds* (Russell & Rubin, 1998) for implementing mathematics instruction. Both Katie and Sara use curriculum that supports a realist world views. Although Katie administers multiplication timed tests, she does not allude to implementing other forms of realist curriculum. Sara used Saxon (Larson, 2004) as her major resource for this mathematic unit while supplementing with Investigations. Although each teacher indicated a preference for a contextualist curriculum, it seemed that their beliefs about curriculum varied even within a contextualist perspective. Sara is a
realist with contextualist tendencies; Jenna supports a contextualist world view, while Katie believes most strongly with the contextualist world view with some aspects of the realist. The common curriculum link for all the individuals is the contextualist world view in terms of utilizing the same curriculum text.

The three teachers also reported implementing a contextualist approach to pedagogy in the mathematics classroom to varying degrees. All of the teachers believe that students should work together to construct knowledge, however not all of the teachers were able to cite specific example of this practice in their classrooms. Katie uses classroom discussions as a vehicle for students to share information with one another. Jenna believes that knowledge can change over time while Katie and Sara disagree with this statement. They believe mathematics is static. Creating an environment where students are encouraged to think independently reflects a relativist world view and is unique because Jenna was the only participant to articulate this belief. Katie and Sara want students to gather and evaluate good from poor arguments, but also support instant recall drills in their classroom practice. Based on the vignette interviews, Katie and Sara endorse a contextualist and realist approach to teaching and learning, however Sara is more deeply rooted in the realist world view while Katie expresses more support for the contextualist worldview. Jenna is similar in that she relates her teaching to the contextualist, but she also claims to espouse a relativist world view. Thus, the common pedagogical perspective share by the case study individuals is the contextualist world view.

Assessment techniques shared by the case study teachers include both contextualist and realist tools. All of the teachers claim to use classroom observations and questioning of students, which supports the contextualist approach. Conversely, each teacher administered recall tests as a means of the realist assessment. Katie went on to say that
she utilized math notebooks to check for student understanding, again demonstrating a contextualist perspective. Joanne shows continued support for contextualist assessments by giving students open-ended tasks. Because the contextualist assessments are subjective, Katie and Joanne state that these assessments are hard to equate into a letter grade. Sara disagrees and believes by using performance assessment she can easily apply a rubric to determine a letter grade, however, she does admit that using realist assessments are more convenient for grading purposes. Through contextualist assessments, the teachers feel that they learn about how students learn, but are conflicted because the realist assessments are more consistent with the school district’s grading system. With this being the case, the teachers utilize realist assessments more for actual grades and focus on contextual assessment informally.

Practice that Provides Evidence of Teachers’ Beliefs

The next section of the analysis looks at the extent to which observations and documents provide evidence of teachers’ beliefs in practice. Based on observations and document data provided by the case study teachers, they all demonstrate a combination of mixed beliefs systems between the realist and contextualist world views. The degree to which each teacher’s practice is representative of these two world views will be examined in this next section. None of the teachers exhibited evidence of the relativist world view in their instructional practice. The relativist world view supports individualized instruction based on the needs of each child. Because the district mandates a set curriculum for each grade level, it is difficult and unreasonable for a teacher to be a relativist teacher can exist with these constraints. The researcher conducted three to four
observations of each teacher during the unit of instruction. Analysis of the field notes provides evidence of world views implemented during mathematics instruction. Based on domain analysis focused on means-end (Spradley, 1980), where characteristics of practice are ways to implement a world view, the researcher determined how the participants practice matched her espoused world views. The analysis consisted of the researcher highlighting aspects of the field notes that reflected characteristics of practice of each world view exhibited in the instruction. The domain analysis reflected two domains: 1) realist world view and 2) contextualist world view. The relativist world view is absent because the observations done for all the case study individuals did not contain individualized instruction. Documentation data that consists of lesson plans; supplemental worksheets and assessments were shared with the researcher to provide further evidence of teachers’ beliefs in practice. The following section is organized around each individual case study teacher.

Case One: Katie

Katie’s classroom consists of students seated in four table groups with 4-5 students at each group. There are two white boards in the front of the classroom and the teacher’s desk is located in the back of the room. A number chart is posted on the front board along with a poster hung in the room that explained place value. Students’ math work is displayed on a bulletin board, which consisted of multiplication story problems designed by the students. The paper contains a word problem, a strategy for solving the problem and a picture to illustrate the math multiplication problem. This work is a sample from a lesson where students were asked to create their own multiplication problems and solutions. The student work is reflective of a contextualist teacher because the students create their own context for the multiplication problem. In addition, there is a posted
labeled multiplication and division club for recording individual scores for the timed tests, which supports a realist world view. Based on the physical environment of the classroom, Katie supports a community of learners, but also emphasizes the importance of instant recall of multiplication facts.

Based on Katie’s lesson plans, most of her lessons consist of activities taken from *Landmarks in the Hundreds* (Russell & Rubin, 1998). She allots an average of 80-90 minutes a day for mathematics instruction. Within this time frame, she starts each math period with a timed multiplication test, followed by a mental math activity and then proceeds to continue with the lesson in her math textbook. This being the case, about ¼ of her math lessons consists of using realist forms of curriculum while the rest of her time is devoted to contextualist forms of curriculum. The following table summarizes the evidence taken from observations and documentation data to support Katie’s world view perspectives in practice.

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<th>Domain One: Realist World View—Pedagogy Examples</th>
<th>Domain Two: Contextualist World Views—Pedagogy Examples</th>
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<td>Teacher questioning</td>
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<td>Teacher sharing strategies</td>
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<td>Teacher telling students to work in a logical order</td>
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<td>Teacher telling student how many factors there are for a number</td>
<td>Teacher providing a real world connection</td>
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<tr>
<td>Teacher corrects student work</td>
<td>Teacher allowing students a choice</td>
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Although Katie’s curriculum choices support a clearer focus on contextualist pedagogy, she tends to combine/blend both the realist and contextualist approaches to
instruction in the classroom. Katie’s use of timed tests is an example of the realist world view. She allows the students one minute to complete a page of multiplication problems with 100% accuracy to pass to the next number. This is a form of drilling students to produce instant recall of multiplication facts.

Other examples of her practice demonstrate using both a contextualist and realist format for implementation. The following example came from field notes taken from the researcher’s first observation. During mental math, Katie put a problem on the board 545 + 320 and asks the students to solve the problem in their heads. The students are instructed to put their thumbs up when they have an answer to share with the whole class. Once most of the students have their hands up, Katie calls on them to share. Katie allows the students an opportunity to share different answers to the problem and explain how they arrive at a particular answer.

Many students in the United States use algorithms for addition, which means adding the ones column first, then adding the tens column, and finally adding the hundreds column vertically to solve the problem. Katie demonstrates a different way to solve the problem. She took off the 45 from 545 and the 20 from 320 and thought about the problem as 500 + 300 = 800 (hundreds place), then she adds 40 + 20 = 60 (tens place) and finally adds the 800 (hundreds place) + 40 (tens place) + 5 (ones place) = 865. The students are encouraged to use this strategy in other mental math problems and/or share other strategies. Although Katie allows students to construct different ways to problem solve, she is the only one to share a different strategy. The concept of mental math supports a contextualist practice, but Katie still approaches the learning environment from a teacher-focused, realist perspective.
The researcher's first three observations of Katie are the continuation of one lesson that involved finding factors for 24, 36, and 48. Katie starts the lesson by asking students different ways to count to ten. The students suggest counting by fives, tens, twos and ones while Katie records these different strategies on the board. She asks the students if there are other ways to count to ten. One student said no because those are the only numbers that make arrays for ten. Katie then writes $1 \times 10$ and $2 \times 5$ on the board and continues the lesson by asking for different ways to count to 20. Students share different ways to count to 20, but when an incorrect counting strategy is shared, Katie has the class skip count by that number to correct the mistake. The lesson continues once Katie has all the factors of 20 listed on the board. She asks the class if they have all the factors and they answer yes, but Katie does not ask how the students knew all the factors are on the board. Katie asks the class what they know about these numbers and one student raises his hand to say they are factors for 20. Katie then asks what are factors, and a student answers, numbers to count by to reach a certain other number. Through questioning, Katie allows students to construct knowledge for themselves.

The lesson continues by Katie asking students to find the factors for the numbers 24, 36, and 48. Students are able to use both cubes and number charts to find the factors for the numbers. The students work independently to make equal groups of the number. Katie is implementing curriculum from a contextualist world view because students are using manipulatives or skip counting charts to help them construct factors for the numbers 24, 36, and 48; however, the students work independently and are not encouraged to construct knowledge in groups or collaborate. Throughout the lesson, Katie tells students that mathematicians like to keep things logical so they should start with one as a factor and then move on from there working in order. For example, the
students are encouraged to start with one, then two and so on until they find all of the factors for a particular number. The students are also given student sheets to write factors for the number. Katie told the students that they have enough space to write all the factors without making a mistake. By doing these things, she is implementing a contextualist curriculum resource from a realist perspective. When students have incorrect factors, Katie tells the students to correct their work until they have all the factors. The same format for the lesson is continued through the first three observations. Katie encourages students to find the factors on their own using cubes and also questioning students about how they find different answers, which supports a contextualist approach to learning. The other aspects of the lesson: telling students how many factors for a number, telling students to work in order, and correcting students work, directly support a realist method of instruction.

There are examples from Katie’s practice that provide more support for a contextualist world view. During the researcher’s third observation of Katie, she assigns the class a homework assignment that asks students to demonstrate groupings of 100 items. The directions are for students to make a picture of 100 things by designating groups of the objects. The students are able to use whatever items from home that they want such as: beans, fruit loops, macaroni, stamps, marshmallows, and paper clips. Katie instructs the students to write a multiplication equation to go with the picture. For example, if the student did 10 groupings of 10, then the multiplication equation is $10 \times 10 = 100$. One example of student work includes 10 groups of 10 using cheerios. The class brainstormed different ways to skip count to 100. Through this assignment, students are given a choice in how they want to group items to 100 along with connecting the item of factors of 100 with real-world objectives. These are both aspects of a contextualist world
view in practice.

Another example from the researcher's fourth observation of Katie involves students exploring ways to split up a dollar. The instructions are for students to record the number of people sharing a dollar and how much each person receives from splitting the dollar evenly. The student sheet given to the students also has an area for students to record ways they try to split a dollar evenly, but did not work. In order to construct this knowledge, the students are encouraged to use prior knowledge about factors of 100 along with manipulating coins to demonstrate the methods for dividing a dollar evenly. The use of hands-on materials and the connection to real world situations mirror the contextualist approach to learning.

Based on domain analysis focused on means-end (Spradley, 1980) where characteristics of practice are ways to implement a world view, the researcher determined that Katie's practice matches her espoused world views. Katie claimed to be a contextualist (domain two) and realist (domain one) in her beliefs about curriculum, pedagogy, and assessment. From her practice, she incorporates both views equally. Katie is able to articulate her practice and further verifies her instruction by being consistent in her teaching.

Case Two: Jenna

Jenna's classroom consists of three long table groups; the middle group contains six students while one side table has seven students, and the other side table group includes eight students. In front of the middle table group, Jenna has an overhead. The objectives for the lesson are written on the front board. Student work in mathematics is not displayed in the room, but a math multiplication game is posted on the front board. In addition, a bulletin board is hung with problems for the student to do on a daily basis. The
problems are recall and consist of different aspects of mathematics, not exclusive to what the class is working on in the current mathematics unit.

Jenna’s lesson plans indicate that she uses *Landmarks in the Hundreds* (Russell & Rubin, 1998) as her only means of instruction during the unit on number sense. On average, she spends 45 minutes on mathematics instruction per day. The daily lay out of her lessons consist of a ten-minute math activity, followed by a review of the previous day’s lesson leading into the current session. Based on this information, most of her instruction supports a contextualist world view. Jenna espouses both a contextualist and relativist world view. Further analysis of her practice reveals a discrepancy between her espoused beliefs and her actual practice. Through the observation data collected by the researcher, it is evident that Jenna demonstrates a mixed approach to classroom practice, which incorporates the contextualist and realist world view. The following table summarizes the practical examples of the world views that is evident in Jenna’s mathematics instruction.

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<th>Domain Two: Contextualist World Views—Pedagogy Examples</th>
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<td>Teacher correcting student work</td>
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Table 8. Jenna’s World Views in Practice
Jenna utilizes a contextualist curriculum to teach her unit of instruction; however, she structures the learning environment from a realist and contextualist approach. Based on the researcher's first observation, Jenna starts the lesson by asking students to skip count around the room. The first student says two, the next one four and so on until they reach the last student in class. The students are asked to predict what number they would land on once they reach the last student, but the students are not asked to explain how they came to those predictions. This is a procedural way to count around the classroom. The lesson continues with Jenna asking the students to list factors of 20, which they have done the day before. Jenna calls on students who have their hands raised to give answers. If the student gives a correct response, she writes this on the board and moves on to the next student, but if a student gives an incorrect response, she corrects them verbally and continues to call on the next student. Through Jenna's practice, it is evident that she values correct answers and tells a student directly if he/she is incorrect. The lesson continues by having students explore the factors of 24. She models how to do the student sheet by asking students for a factor of 24. One student suggests 4, so Jenna instructs the class to skip count by four on the student sheets by coloring in every fourth number. She then asks the class if four is a factor of 24, and one student said no, so Jenna went over to his work and corrects his skip counting. Again, this provides support for a realist approach to learning. The contextualist teacher allows students to share answers through explanations and further questions students, so that they can learn from incorrect responses. The process of learning is focal, not just the product. Throughout the observations, Jenna asks lower-level questions which allows student one word answers. Such questions include the following: 1) Is 4 a factor of 24? 2) Do we have all of the factors for 24? and 3) How many sixes are in 24? The students contribute an answer, but
are never pushed further to explain their thinking.

In these same lessons, Jenna exhibits some examples of contextualist practice. She allows students to find factors for 24, 36, and 48 by using cubes and skip counting charts. The students work together and use manipulatives to construct knowledge. Because students are allowed to use cubes to find factors, they are engaged in the learning environment. Another example of contextualist teaching is based on the third observation of Jenna. The lesson involves allowing students to split 100 pennies in equal groups. The students are encouraged to work together using coins to find way to split 100 pennies in equal groups. This lesson provides a real world connection by using money. The contextualist teacher supports students working together, the use of manipulatives and connecting math to a real-world context. Jenna did, however, tell the students that they should work in order during this lesson meaning first try one group of 100 pennies, then two groups, and so on until they had all the possible combinations. This is an example of the realist approach to learning because the contextualist teacher allows students to explore with different number combinations not in a particular order.

The researcher’s fourth observation of Jenna involves the opportunity to check for student understanding of factors of 100. This lesson is taken directly from the teacher checkpoint in *Landmarks in the Hundreds* (Russell & Rubin, 1998). She tells the students that she will write two questions on the board for the students to work on. The students are told they can use drawings, numbers, money, cubes, skip counting charts, or anything else they want to solve the questions. The following questions are written on the board:

1. How many 20’s are in 100?

2. How many 4’s are in 100?
Jenna tells the students to work on the questions and prove their answers. Many students, 14 out of the 18 students, choose to use manipulatives including cubes and/or money and only four out of the 18 students work alone. Jenna walks around the room to monitor students’ work and ask questions. Some students build models using cubes and/or money and then draw models, while other students write about how they skip count using numbers, such as, 20, 40, 60, 80, and 100. If a student uses cubes, he/she makes groupings of 20 until reaching 100 and repeats the same process for groupings of 4 cubes. The following two pictures are examples of how students illustrate these problems:

**Problem 1:** 20 x 5 = 100

```
XXXXXXXXXXXXXXXXXXXXX 20
XXXXXXXXXXXXXXXXXXXXX 40
XXXXXXXXXXXXXXXXXXXXX 60
XXXXXXXXXXXXXXXXXXXXX 80
XXXXXXXXXXXXXXXXXXXXX 100
```

**Problem 2:** 4 x 25 = 100

```
XXXX 4  XXXX 8  XXXX 12  XXXX 16  XXXX 20
XXXX 24 XXXX 28  XXXX 32  XXXX 36  XXXX 40
XXXX 44 XXXX 48  XXXX 52  XXXX 56  XXXX 60
XXXX 64 XXXX 68  XXXX 72  XXXX 76  XXXX 80
XXXX 84 XXXX 88  XXXX 92  XXXX 96  XXXX 100
```

This is an example of a contextualist teacher using an assessment to monitor how students problem solve.

Domain analysis (Spradley, 1980) reveals that Jenna demonstrates characteristics of realist (domain one) and contextualist (domain two) practices in her teaching. This is
contrary to what she espouses during her interviews. Although she does claim to implement contextualist practices, this is not her only means of instruction. Jenna is not aware of how her pedagogical practice supports a realist approach to instruction; therefore, inconsistencies exist between her stated beliefs and her actual practice.

**Case Three: Sara**

Sara’s classroom is set up with one long table that runs vertical to the front board and seats 12 students. The other table, which has seating for 8 students, is set up like the letter T, the long end facing the front board. Posted on one wall is a teacher-made poster that reads “Fractions That are Equal,” which lists equivalent fractions such as $\frac{1}{4} + \frac{1}{4} = \frac{1}{2}$. This particular poster comes from a previously implemented Investigations book focusing on fractions. Thus, the poster provides support for contextualist-type lessons. Another area of the room has a multiplication chart to keep track of the students who pass the daily time tests. On the front board, the objectives for each math lesson are posted along with math tasks for the students to complete daily. The students complete these problems in their math journals; the tasks were part of the class math meeting and include: the date, the problem of the day, a time problem from a picture clock, a money problem, a pattern of the day, and a number of the day. These are all examples of realist-type activities that involve product driven answers.

Based on Sara’s lesson plans, she spends half of her time during this unit teaching from *Landmarks in the Hundreds* (Russell & Rubin, 1998) and the other half from Saxon Math (Larson, 2004). The average length of her math lessons is between 60-75 minutes. During the Investigations lesson, she starts with an introduction that incorporates a review of the previous day’s lesson along with the objectives for the current lesson, followed by a lesson development activity, closure, and ending the lesson with a time
test. Conversely, the Saxon Math day's lesson consists of a math meeting, a lesson introduction, a development lesson, and a closure, which includes homework assignments. Based on this information, she combines the realist and contextualist practice in her instruction. The following table provides evidence of practice that supports Sara's world views.

Table 9. Sara's World Views in Practice

<table>
<thead>
<tr>
<th>Domain One: Realist World View—Pedagogy Examples</th>
<th>Domain Two: Contextualist World Views—Pedagogy Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher asking lower-level questions</td>
<td>Students working with manipulatives to construct knowledge</td>
</tr>
<tr>
<td>Teacher giving correct answers to students</td>
<td>Teacher valuing incorrect student responses as a way to look at the process of learning</td>
</tr>
<tr>
<td>Teacher telling students to work in a logical order</td>
<td>Teacher using open-ended informal assessments with students</td>
</tr>
<tr>
<td>Teacher values right answers only</td>
<td></td>
</tr>
<tr>
<td>Teacher correcting student work</td>
<td></td>
</tr>
<tr>
<td>Teacher modeling a strategy</td>
<td></td>
</tr>
<tr>
<td>Teacher drilling student recall</td>
<td></td>
</tr>
<tr>
<td>Students working independently</td>
<td></td>
</tr>
<tr>
<td>Student timed tests</td>
<td></td>
</tr>
<tr>
<td>Students copying teacher's work</td>
<td></td>
</tr>
</tbody>
</table>

Sara uses realist and contextualist curriculum resources in teaching mathematics. Although she does demonstrate some contextualist practices in her teaching, most of the characteristics of her practice align with the realist world view. During Sara's first observation, she has students review the factors they found for the number 20. Students contribute different answers, which Sara writes on the front board. When a student gives an incorrect response, Sara asks why the number is not a factor. One student says three is not a factor of 20 because when skip counting, you do not land on twenty. Sara writes
three on the board and labels it an “outlaw” number and lists other incorrect responses under this heading. Thus, Sara shows value for incorrect responses as a way to examine why a particular number is not considered a factor. The lesson continues by Sara explaining and modeling how the class finds factors for 24. She encourages the student to use cubes and skip counting to determine the factors of 24. Students are working with manipulatives to construct knowledge of factors. These characteristics support a contextualist approach to learning.

Through examination of Sara’s assessment documents, she provides support for using contextualist methods of assessment. Sara implements the end-of unit assessment tasks for *Landmarks in the Hundreds* from the *Assessment Sourcebook* (TERC, 2001). These open-ended assessment tasks are designed to assess students’ understanding of the most important mathematical ideas covered in curriculum unit. Based on these four assessments, Sara constructs a point rubric to equate the students’ performance on these tasks into a letter grade. By providing the researcher this system for evaluating students, Sara implements contextualist forms of assessment in her classroom practice.

Sara claims that most of her teaching reflects a realist perspective, which is concurrent with most of her observations and documentation data. In the above lesson, students are encouraged to find factors of 24; however, the teacher tells the students that they need to work in a logical order to find the factors, mandating how the students should construct knowledge of factors. The students are encouraged to work in groups, but only as a way to share what number they have tried with their partner. It is not apparent that students actually work together to construct knowledge of factors; they simply share answers with one another and work separately. After the class lists all of the factors, Sara instructs the students to copy the list of factors from the board. Instead of
discussing how the class came to know if they had all the factors for a particular number, Sara tells the class once all the factors are listed. On day two, students are continuing to find factors for 36 and 48 in the same way as they did for 24, Sara walks around the class during independent work time to correct students’ work. If students list an incorrect factor, Sara points out the problem and asks if the students do not have all the factors, Sara tells the students which other numbers they should try. These are examples of how a contextualist curriculum is implemented from a realist perspective.

The rest of the observations are from watching Sara implement a realist curriculum, Saxon (Larson, 2004), from a realist approach to learning. In every observation, students were observed taking a timed multiplication test to reinforce recall of basic factors, in addition to students working independently throughout all of the lessons. Part of Saxon (Larson, 2004) involves students completing several daily problems on the board. These problems include a word problem, finding the pattern of the day, determining the time on a clock, calculating the money total, reading the temperature, and writing an equation for the number of the day. All of these problems are recall driven and Sara asks lower-level questions to check for understanding. These lower level questions include: 1) What was the date seven days ago? 2) What will the day of the week be when it is the 17th? 3) How many days are in March? and 4) How many days are in a leap year? The questions are asked to determine a correct response, but do not focus on how or why the students give their response. When a student gives an incorrect answer, Sara corrects the students and tells them to check their work again. Sara models how to solve the problems using one algorithmic method.

During Sara’s third observation, the students complete the board tasks, and then take a subtraction test for the numbers 7, 8, and 9. The students are given 1 ½ minutes to
complete the sheets and then Sara collects the page to be corrected later. For the next part of the lesson, Sara tells the students that when they multiply by zero the answer will always be zero. She puts several examples of multiplication problems on the board and asks the students for the answer. Each problem has a zero multiplied by another number. To continue with the lesson, the students are given a multiplication worksheet that contains multiplying by fives. Again, students write answers to the problems and then continue to practice multiplying by five using a wrap up stick. This is a stick that the students wrap their answers for the fives multiplication problems, then flip the wrap up over to check their answers. If the answer is correct, then the answer the student selects matches the line indicated on the back of the wrap up. Students are put into pairs and told to race each other to determine who can recall the fives multiplication facts first. In this classroom, students are encouraged to compete as a motivator for learning rather than working in a collaborative environment. Students are then given another worksheet to find the missing factor for multiplying by and fives. Upon completion of this worksheet, Sara passes out a homework sheet that again reinforces recall skills. This lesson is an example of a typical Saxon (Larson, 2004) math lesson, which reflects a realist world view and is consistent with Sara’s teaching practice in mathematics.

A means-end domain analysis (Spradley, 1980) based on observations and documentation data reveals that Sara implements a realist perspective to learning with some minimal characteristics of contextualist practice in mathematics. In Sara’s initial vignette interview, she espouses a realist and contextualist world view in beliefs about curriculum, pedagogy, and assessment. Through analysis of her practice, she is consistent with her espoused beliefs. Sara can articulate her beliefs and demonstrates support for these beliefs throughout her mathematics instruction.
Conclusion

Findings based on domain analysis reveal that two of the case study teachers (Katie and Sara) demonstrate consistencies between espoused beliefs and practice; however, one case study teacher (Jenna) presents an inconsistency between espoused beliefs and practice. Katie indicates that she supports a contextualist and realist world view in curriculum, pedagogy, and assessment. Observation of her practice confirms that she supports these views through mathematics instruction; however, she verbally supports this view more than her practice indicates. Sara endorses a realist worldview with some acceptance of the contextualist perspective, which corresponds directly to her mathematics practice in the classroom. Conversely, Jenna espouses using a contextualist curriculum through pedagogical methods that support both a contextualist and relativist approach to learning, while utilizing assessments that exhibit a contextualist and realist world view. The only stated consistency in all three areas of curriculum, pedagogy, and assessment support a contextualist framework. Based on her practice, Jenna demonstrates a mostly realist practice with some examples of contextualist methods. The next section will address why these case study teachers have consistencies and inconsistencies between their espoused beliefs and actual practice.

Exploration of the Relationship Between Teachers’ Beliefs in Mathematics and Their Instructional Practice

Ideal beliefs differ from espoused beliefs because an ideal belief is how a teacher truly believes mathematics should be taught; whereas, espoused beliefs are how the teacher sees herself implementing curriculum, pedagogy, and assessments. Some of this
tension exists based on constraints in the teaching environment. This next section addresses factors that influence practice based on the case study teachers’ ideal beliefs. Analysis of mid and final interviews during Phase II provide evidence of the teachers’ ideal beliefs and factors that impact practice. The following table lists the relationship between espoused beliefs, actual practice and ideal beliefs for the case study teachers.

Table 10. The Relationship Between Beliefs and Practice in Mathematics

<table>
<thead>
<tr>
<th>Case Study Teacher</th>
<th>Espoused Beliefs</th>
<th>Actual Practice</th>
<th>Ideal Beliefs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Katie</td>
<td>Curriculum, Pedagogy, and Assessment: Contextualist and Realist</td>
<td>Curriculum, Pedagogy, and Assessment: Contextualist and Realist</td>
<td>Curriculum, Pedagogy, and Assessment: Contextualist</td>
</tr>
<tr>
<td>Jenna</td>
<td>Curriculum: Contextualist</td>
<td>Curriculum, Pedagogy, and Assessment: Realist and Contextualist</td>
<td>Curriculum, Pedagogy and Assessment: Contextualist</td>
</tr>
<tr>
<td></td>
<td>Pedagogy: Contextualist and Relativist</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Assessment: Realist and Contextualist</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sara</td>
<td>Curriculum, Pedagogy and Assessment: Realist and Contextualist</td>
<td>Curriculum, Pedagogy and Assessment: Realist and Contextualist</td>
<td>Curriculum, Pedagogy and Assessment: Contextualist</td>
</tr>
</tbody>
</table>

Domain analysis (Spradley, 1980) focusing on rationale was conducted by the researcher. The domains were determined by highlighting case study individual’s interview transcriptions, field notes from observations and documentation data. The results yielded X factors that influence practice, is a reason for doing or not doing Y, mathematics instruction. The specific mathematics instruction that was analyzed for each case study individual embodied the contextualist world view. This was determined
because each participant indicated the contextualist world view as the ideal form of practice because all the case study individuals indicated that they believe students learn best by constructing knowledge through hands-on manipulatives. From the domain analysis, many factors supported and hindered practice. The researcher categorized these domain based on broad external factors to narrow internal factors. The following domains were examined based on the data: 1) domain one: school district factors, 2) domain two: school culture factors, 3) physical classroom factors, and 4) domain four: individual teacher belief. The following section was organized around analysis of each case study teacher.

Case One: Katie

Throughout Katie’s interviews and observations, she is consistent between what she espoused and what is evident in her practice. She supports the contextualist world view with some aspects of the realist world view. When discussing her ideal beliefs, Katie supports a contextualist perspective in curriculum, pedagogy and assessment. Katie addresses her ideal belief about assessment:

In a perfect world, I think that students should be assessed on their thinking, on what they say, on what they can demonstrate, on what they can write, how they explain their thinking, so that you can see what they know. Even if they do not know the complete answer, where do they break down in their thinking? What else can you offer to help them improve their thinking? So much of what we have to do as teachers requires grading, this is why on those factor pages (prior lesson), I actually put a number to it and record points because it seems easier to do that (Final interview, p. 6).
Katie struggles with what she believes about assessing students and how to approach mathematics instruction because of the pressure to assign a grade to a given task. This is where her practice reflects a realist approach. Katie explains how she defines beliefs and practice. “Beliefs are how you feel things should be, how you feel the information should be presented, what experiences the kids should have, what they should know, how they learn best and practice would be how it really comes to being done” (Final interview, p. 8). Again, Katie mentions the pressure to teach in a particular manner that differs from her ideal beliefs. She states support for the contextualist world view more strongly than the realist perspective; however, due to factors that influence practice, she demonstrates a more balanced approach between the contextualist and realists in her classroom practice. Ideally, Katie endorses a contextualist world view, but several factors influence her actual mathematics instruction. The following table lists factors that influence practice based on Katie’s ideal beliefs structure (contextualist world view).
Table 11. Katie: Factors That Influence Practice Based on Ideal Beliefs Structure

<table>
<thead>
<tr>
<th>Factors That Support Practice Based on Ideal Beliefs Structure</th>
<th>Factors That Hinder Practice Based on Ideal Beliefs Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Domain One: School district</strong></td>
<td><strong>Domain One: School district</strong></td>
</tr>
<tr>
<td>Standardized test scores.</td>
<td>Standardized test scores.</td>
</tr>
<tr>
<td>Testing pressure to teach instant recall of mathematics.</td>
<td>Testing pressure to teach instant recall of mathematics.</td>
</tr>
<tr>
<td>Implementing a mandated curriculum, limited time to teach concepts.</td>
<td>Implementing a mandated curriculum, limited time to teach concepts.</td>
</tr>
<tr>
<td><strong>Domain Two: School culture</strong></td>
<td><strong>Domain Two: School culture</strong></td>
</tr>
<tr>
<td>Teacher given more time to develop concepts.</td>
<td>Teacher not supported by peers.</td>
</tr>
<tr>
<td>Teacher supported by administration, teacher supported by peers.</td>
<td>Parental pressure to instant recall.</td>
</tr>
<tr>
<td>School goals support teacher’s perspective.</td>
<td></td>
</tr>
<tr>
<td>Teacher access to materials.</td>
<td></td>
</tr>
<tr>
<td><strong>Domain Three: Physical classroom</strong></td>
<td><strong>Domain Three: Physical classroom</strong></td>
</tr>
<tr>
<td>Limited classroom space.</td>
<td>Limited classroom space.</td>
</tr>
<tr>
<td>Distribution of materials.</td>
<td>Distribution of materials.</td>
</tr>
<tr>
<td><strong>Domain Four: Individual teacher belief</strong></td>
<td><strong>Domain Four: Individual teacher belief</strong></td>
</tr>
<tr>
<td>Students justifying thinking through discussions.</td>
<td>Student’s ability to learn.</td>
</tr>
<tr>
<td>Students constructing different solutions to problem solving.</td>
<td>Student’s behavior in the classroom.</td>
</tr>
<tr>
<td>Students understanding concepts more deeply.</td>
<td></td>
</tr>
<tr>
<td>Teacher’s ability to ask good questions.</td>
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</tbody>
</table>

Katie states many factors that support her contextualist practice in the mathematics classroom. She talks about how her beliefs about students, domain four-individual teacher belief, provide justification for why she implements contextualist practices.

I want them to feel like they are allowed to think, they are allowed to solve, they are allowed to discuss, and they are allowed to argue their thoughts. I think that we need critical thinkers, and people that can support their thinking. Why do you think this is
right? Why do you think this is wrong? How would you do it differently? Even if they offer a wrong answer, just by justifying the wrong answer, we can find out what they know and where their thinking breaks down. I want them to construct their own knowledge. I honestly think this how they grow (Final interview, p. 7).

Katie wants students to justify their thinking and to discuss different solution to problems in order to understand concepts more deeply. "I feel like the way I am teaching takes longer to get from point A to point B, but when the kids get to point B, they will have a better handle on the concepts" (Mid-interview, p. 3). Through questions that ask students why or how they came to a particular solution, Katie pushes the children’s thinking.

School culture (domain two) also influences how Katie approaches the mathematics classroom. Because Katie is given access to concrete materials she allows students to construct knowledge with the use of manipulatives. She also feels supported by the administration and her peers. “My principal believes in how I teach, getting the thinking going, getting discussions going, problem solving which is one of the school goals, so obviously, the way I teach fosters that, so I think that helps my view (contextualist)” (Mid-interview, p. 3). Katie also mentions that she has modeled mathematics lessons for her peers, which means other teachers are interested in these approaches to teaching. Due to many of these supportive school culture factors (domain two), Katie is able to implement contextualist approaches to learning mathematics in her classroom.

Katie describes many factors that hinder her ability to teach mathematics in a contextualist manner, which is why she feels pressure to teach from a realist world view. One of the biggest issues for Katie is testing, domain one-school district:

I think education has changed a lot and we are really under the pressure of testing and we have got to meet all those goals, or all those test scores. I am starting to feel like I
have to abandon some of the ways I do things (contextualist) just to get some skills quickly into the students (realist). I just make sure that I cover the benchmarks. I will get them so they know those skills, so that I do not get in trouble. I cannot even teach the way I want to sometimes (Mid-interview, p. 3).

By having a mandated curriculum, the pressure to teach instant recall of mathematics facts and a focus on students’ standardized test scores, Katie resorts to teaching from a realist perspective.

Although Katie does have access to manipulatives (domain three-physical classroom), she complains that it is difficult to organize and distribute materials in a timely manner. Throughout Katie’s interviews, she makes reference to needing more space to allow students areas to spread out and work with materials (domain three-physical classroom). This provides a hindrance to implementing a contextualist curriculum.

Katie also discusses her perspective (domain four-individual teacher) on the students’ ability to learn along with behavior issues with students. When asked what hinders her from teaching in the ways her wants to teach, Katie said:

Grading, testing, student behavior, and parents, just their ignorance of how there might be another way to teach then just a worksheet because a lot of them think you are supposed to have worksheets, that is what we had when we were little and that is what they are looking for. You don’t always have the time, or maybe the kids don’t come up with what you are trying to get them to come up with. You try to lead them to some of that, but they don’t come up with the solutions or the strategies that you are trying to get them to think of, so sometimes you have to tell them (Final interview, p. 9).
Due to limited time for instruction (domain one-school district), Katie believes that she has to tell the students the answer or the way to solve a problem instead of allowing student to construct knowledge or their own.

The parents (domain two-school culture) are another outside influence that provides pressure for Katie to teach in a traditional manner. Because Katie teaches from a contextualist approach, many teachers are interested in how she structures the mathematics lessons; however, this also provides a concern for Katie. “It would help if I felt like more teachers at my grade level believed how I believe. I feel like I am a little out there, like maybe I am going after the wrong thing, or I am having the wrong goals” (Mid-interview, pp. 2-3). By taking a leadership role in the school and having teachers view her teaching mathematics, Katie is proving to be a risk taker. She feels isolated from her peers, which causes her to resort to realist practices.

Katie discusses factors that support and hinder her practice as a contextualist teacher. Her actual practice combines both the contextualist and realist world view lead to a more balanced approach, but does reflect more of a contextualist approach to learning. Based on the interview data, Katie has about the same number of factors that support her teaching mathematics from a contextualist world view as factors that hinders this approach to learning.

Case Two: Jenna

Based on Jenna’s interviews and observations, she demonstrates inconsistencies between her espoused beliefs and practice. Jenna espoused a contextualist world view in curriculum, pedagogy, and assessment; however, she also supported relativist practices in her mathematics instruction, along with realist forms of assessment. By examining Jenna’s classroom practice, she demonstrates both realist and contextualist methods of
instruction. When discussing her ideal beliefs, Jenna talks about the relativist world view, but through her interviews, provides evidence for also endorsing contextualist practice as an ideal:

Ideally, I would still think that I am a relativist, but like I said, it doesn’t really fit into our curriculum. I would like to teach this way and feel like I try to teach this way, but there are a lot of issues that go on that prohibit this type of teaching in the classroom. I do try to make the students think independently. If we are doing our job right, we try to teach the students to become critical thinkers in society (contextualist world view) when they grow up (Final interview, p. 5).

One aspect of the relativist perspective that Jenna does not make reference to is individualizing instruction for each child. This is the foundation of the relativist belief, which leads the researcher to believe that Jenna misinterpreted the relativist perspective. The relativist teacher cannot exist within a school district that mandates standardize curriculum and assessment. Jenna makes reference to the tension that exists in wanting to teach the way she believes is most effective as opposed to the pressures that restrict contextualist practice.

It’s funny because there are state tests, national tests, everything is paper and pencil and it is a multiple choice, but I know that the best way to teach math is hands-on. They (the students) have got to write and explain (their thinking) and discuss by working with a partner, but our test is paper and pencil, so they contradict each other (Final interview, p. 3).

When Jenna discussed factors that either support or hinder her ideal practice, she referred to the contextualist world view. The following table lists factors that influence Jenna’s
practice based on her ideal beliefs structure as related to the contextualist world view.

Table 12. Jenna: Factors That Influence Practice Based on Ideal Beliefs Structure

<table>
<thead>
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<td>Testing pressure to each instant recall of mathematics.</td>
</tr>
<tr>
<td>Implementing a mandated curriculum.</td>
<td>Implementing a mandated curriculum.</td>
</tr>
<tr>
<td>Limited time to teach concepts.</td>
<td>Limited time to teach concepts.</td>
</tr>
<tr>
<td>Accountability for each standard.</td>
<td>Accountability for each standard.</td>
</tr>
<tr>
<td><strong>Domain Two: School culture</strong></td>
<td><strong>Domain Two: School culture</strong></td>
</tr>
<tr>
<td>Teacher given more time to develop concepts.</td>
<td>Teacher access to materials.</td>
</tr>
<tr>
<td>Teacher access to materials.</td>
<td>Pressure from administration to teach instant recall of basic facts.</td>
</tr>
<tr>
<td>School support for implementing a contextualist curriculum resource.</td>
<td></td>
</tr>
<tr>
<td><strong>Domain Three: Physical classroom</strong></td>
<td><strong>Domain Three: Physical classroom</strong></td>
</tr>
<tr>
<td><strong>Domain Four: Individual teacher belief</strong></td>
<td><strong>Domain Four: Individual teacher belief</strong></td>
</tr>
<tr>
<td>Students using hands-on materials to explain and discuss thinking.</td>
<td>Students' ability to learn (ELL).</td>
</tr>
</tbody>
</table>

Jenna listed several school culture factors (domain two) that support her contextualist practice in the mathematics classroom. When asked what helps her teach in the ways that she wants to teach, she said having more time. The school expects that the teachers implement the Investigations series (TERC, 1998), which again provides support for a contextualist approach to learning. “To make sure we get through all of the units in Investigations, we are given long range plans to make sure you spend a certain X amount of weeks for a particular book, to make sure you are able to get in all of the books” (Mid-interview, p. 6). The school administration mandates that the teachers in this school use a
contextualist curriculum to meet the state standards for mathematics education. By having her materials organized and having centers laid out for the students, Jenna is able to encourage students to construct knowledge of mathematics. In this way, students are using hands-on materials to explain and discuss their thinking (domain four-individual teacher belief).

After viewing a video taped clip of Jenna’s instruction with her from *Landmarks in the Hundreds* (Russell & Rubin, 1998) from the previous year, she was surprised by what was apparent from her practice.

Basically, I saw myself teaching kids out of a book, a workbook. I did not see much interaction with the kids; they did not do a lot of partner things, or brainstorming. It looked like I was just going through whatever page they were in the workbook. I was making them answer on their own without any discussion. I wasn’t asking them to show me different ways to get to a number; it was pretty much just that one way which was in the workbook, and so I would say it would be the realist world view because I did not give them much choice on how to get to the goal, the answer (Mid-interview, p. 1).

She said that this was reflective of the realist world view even though the contextualist perspective supported the curriculum used. Throughout this interview, Jenna referred to herself as a hypocrite because her espoused beliefs that were not consistent with her classroom practice. She was not sure why she approached the lesson in this manner, but did say that based on watching the video that she would not approach the lesson in a realist fashion in the future:

It was enlightening to see that (the video) and I told other teachers about it because it makes sure that you are not going to do that again, no matter how pressed for time
you are, or how much lack of materials you have. That was an awful thing to watch (Mid-interview, p. 5).

Again, Jenna is supporting a contextualist world view in mathematics practice. Based on the researchers observations made from the same lesson this year, Jenna did demonstrate more of a contextualist approach to learning (previously discussed in the prior research question).

Jenna described many factors that hinder her ability to teach mathematics from a contextualist world view. Jenna is limited with the amount of time she is allocated to teach the mathematics concepts (domain one-school district). In addition, there is a limited supply of hands-on materials (domain two-school culture) that students use to construct knowledge of the mathematics content. Many of the students are second language learners (domain four-individual teacher belief), which Jenna views as an impediment to their ability to learn because they have difficulty communicating mathematically through writing. Jenna claims the major reasons she has problems implementing mathematics through a contextualist world view are school district factors (domain one): 1) accountability for each standard, 2) students standardized test scores, and 3) pressure from testing and administration to teach instant recall of basic mathematics facts. Each of these factors involves restrictions based on standardized testing.
We have got so much to fit in, so many objectives, so many standards in a particular time frame. We had a meeting last night and there was a teacher, whose strength is skill and drill. We looked at her results from our state tests and she blows people out of the water (with her high scores) and that is what counts. Unfortunately, that is what makes our principal happy, so it's really difficult to balance the contextualist and realist type because they are getting tested that way (realist), but then you want to teach them a different way (contextualist) (Final interview, p. 6).

Throughout her interviews, Jenna discusses the tension between how she wants to teach mathematics and how she believes she must teach mathematics. The two biggest factors that create a barrier to contextualist implementation are time and testing (domain one-school district).

Jenna discusses factors that support and hinders her contextualist approach to mathematics instruction. Based on her actual practice, examples of both the realist and contextualist world view were found. By examining the factors Jenna discussed in her interviews, she believes there is more hindrance to implementation than factors that support her contextualist practice.

Case Three: Sara

Interview and observation data reveals that Sara is consistent between her espoused beliefs and practice. She endorses and supports through practice both the realist and contextualist world views in mathematics curriculum, pedagogy, and assessment. Sara most strongly espouses the realist practice, which is also evident from examples taken from observation data. Conversely, Sara’s ideal beliefs support a contextualist perspective.
I do, in my heart, wish we had a much bigger classroom, where we could have
different learning areas, and we could have a big rug area where we could sit in a
group and discuss. You could also have your small groups working, but it doesn’t
work out in the real classroom because you have a limited amount of space, a limited
amount of time, and a limited amount of man-power. One teacher can’t give every
student individual attention, work with small groups all the time, and work with
students who need remediation, one-on-one. I think it is really important to have all of
those things. I think it is really important in the contextualist world view and I wish I
could just do that all the time (Final interview, p. 2).

Although Sara’s practice most strongly supports the realist world view, she still believes
the contextualist world view is more effect for teaching students mathematics. The
following table lists factors that influence practice based on Sara’s ideal beliefs structure
(contextualist world view).
Table 13. Sara: Factors That Influence Practice Based on Ideal Beliefs Structure

<table>
<thead>
<tr>
<th>Factors That Support Practice Based on Ideal Beliefs Structure</th>
<th>Factors That Hinder Practice Based on Ideal Beliefs Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Domain One: School district</strong></td>
<td><strong>Domain One: School district</strong></td>
</tr>
<tr>
<td>Professional development offered to the teacher.</td>
<td>Standardized test scores.</td>
</tr>
<tr>
<td></td>
<td>Testing pressure to teach instant recall of mathematics.</td>
</tr>
<tr>
<td></td>
<td>Limited time to teach concepts.</td>
</tr>
<tr>
<td></td>
<td>Teacher’s need for additional assistance from a classroom aid (student-teacher ratio).</td>
</tr>
<tr>
<td></td>
<td>Teacher having to teach all subjects, not just mathematics.</td>
</tr>
<tr>
<td><strong>Domain Two: School culture</strong></td>
<td><strong>Domain Two: School culture</strong></td>
</tr>
<tr>
<td>Teacher given more time to develop concepts</td>
<td>Teacher not supported by peers.</td>
</tr>
<tr>
<td>School goal supports problem solving.</td>
<td></td>
</tr>
<tr>
<td><strong>Domain Three: Physical classroom</strong></td>
<td><strong>Domain Three: Physical classroom</strong></td>
</tr>
<tr>
<td></td>
<td>Limited by classroom space.</td>
</tr>
<tr>
<td><strong>Domain Four: Individual teacher beliefs</strong></td>
<td><strong>Domain Four: Individual teacher beliefs</strong></td>
</tr>
<tr>
<td></td>
<td>Students’ ability to learn.</td>
</tr>
<tr>
<td></td>
<td>Students do not work well together in groups and/or partners.</td>
</tr>
</tbody>
</table>

Sara stated three factors that support her contextualist practice in the mathematics classroom. First, Sara discussed how professional development offered by a National Science Foundation (NSF) grant (domain one-school district) allowed her to reflect on what she was doing in the unit in order to assist her students in learning the mathematical concepts. Second, school culture (domain two), because the school’s weakest area, as indicated from testing, was problem solving. Directing attention to this area became a school-wide goal. The majority of teachers in the school implement mathematics from a realist world view, while Sara makes an attempt to incorporate the contextualist along
with the realist perspective in her classroom. She feels that by teaching in a contextualist manner, the students will have hands-on experiences that will help them in problem-solving situations.

Third, Sara believes having more time (domain one-school district) to develop conceptual knowledge would support her in the ways she wants to teach mathematics. “In a perfect world, if you had all kinds of time, it would be wonderful to give them (the students) a problem or task and say, figure this out with any method you can and tell me how you did it” (Mid-interview, p. 5). By providing Sara with more time to develop the mathematical concepts with students, she believes this would support a contextualist practice.

Sara describes several factors that hinder her ability to teach mathematics from a contextualist world view which lead to her instruction representing a realist world view instead. When Sara spoke about her students specifically (domain four-individual teacher belief), she said that they do not work well together in groups and/or with a partner. An example of this was supported by the observation data shared in research question two. She also questioned some of her students’ ability to learn mathematics when they were required to communicate ideas through written language:

Investigations does not have enough computation in it, the things that they have to know when they are taking a test, like a CRT test, or the IOWA (state mandated testing), so we need to pull in from other programs. Investigations is wonderful at problem solving, but for students that can’t read, that are special education students, students who have a low IQ or English Language Learners (ELL) struggle with that. It is a problem because there is a lot of writing in Investigations and also if you have a
group that doesn’t work together, it is hard because there are cooperative learning opportunities (in contextualist type lessons) (Mid-interview, p. 6).

This response from Sara also provides the researcher with support for the pressure teachers feel due to testing (domain one-school district). Teaching to the test requires Sara to drill basic recall of multiplication facts with her students.

Sara makes reference to the need for more man-power (domain one-school district) so that she can provide small group and individual attention. Through the interviews, she discusses the need for a classroom aid (domain one-school district) in order to lower the student-teacher ratio. Sara believes she is hindered by the size of her classroom (domain three-physical classroom), and the amount of time given for teaching mathematics (domain one-school district). Furthermore, Sara states she would benefit from having to focus on one subject, mathematics, instead of teaching all of the content areas in the elementary classroom (domain one-school district). “If all you taught was math, you could really refine the way you teach things. If you had a block period just for math, you would have more time to do things and basically having a bigger classroom and fewer kids or more help” (Final interview, p. 3). The last factor that influences Sara is her peers (domain two-school culture). The third grade teachers’ plan for lessons together and Sara is the only one to consider contextualist approaches to instruction in the mathematics classroom.

Sara discussed factors that support and hinder her practice as a contextualist teacher. Her actual practice combines both the contextualist and realist world view, but does reflect more of a realist approach to learning. Based on the interview data, Sara has more factors that hinder her teaching mathematics from a contextualist world view as opposed
to those factors that support this approach to learning.

Conclusion

Findings based on domain analysis reveal factors that influence the case study teachers’ practice in the mathematics classroom. All of the case study teachers expressed needing more time with the students to develop mathematical concepts (domain two-school culture). Having the school support (domain two-school culture) the contextual worldview through school goals and/or curriculum textbooks was another factor that all three teachers addressed. Katie and Jenna both found it important to have access to hands-on materials (domain two-school culture) so that student can construct knowledge through problem solving situations (domain four-individual teacher belief). The following tables list common factors that the cases study teachers stated through interviews that support and hinder the contextualist world view.

Table 14. Common Factors That Support Contextualist World View

<table>
<thead>
<tr>
<th>Common Factors Mentioned By All Case Study Teachers</th>
<th>Common Factors Mentioned by Katie and Jenna</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domain One: School district</td>
<td>Domain One: School District</td>
</tr>
<tr>
<td>Domain Two: School culture</td>
<td>Domain Two: School culture</td>
</tr>
<tr>
<td>Teacher given more time to develop concepts</td>
<td>Teacher access to materials</td>
</tr>
<tr>
<td>School support (goal-problem solving, contextualist curriculum)</td>
<td></td>
</tr>
<tr>
<td>Domain Three: Physical classroom</td>
<td>Domain three: Physical classroom</td>
</tr>
<tr>
<td>Domain Four: Individual teacher belief</td>
<td>Domain Four: Individual teacher belief</td>
</tr>
<tr>
<td>Students constructing knowledge through hands-on/problem solving experiences.</td>
<td></td>
</tr>
</tbody>
</table>
Table 15. Common Factors That Hinder Implementing a Contextualist World View

<table>
<thead>
<tr>
<th>Common Factors Mentioned By All Case Study Teachers</th>
<th>Common Factors Mentioned By Katie and Jenna</th>
<th>Common Factors Mentioned By Katie and Sara</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domain one: School district</td>
<td>Domain one: School district</td>
<td>Domain one: School district</td>
</tr>
<tr>
<td>Standardized test score. Testing pressure to teach instant recall of mathematics. Limited time to teach concepts.</td>
<td>Implementing a mandated curriculum.</td>
<td></td>
</tr>
<tr>
<td>Domain two: School culture</td>
<td>Domain two: School culture</td>
<td>Domain two: School culture</td>
</tr>
<tr>
<td>Domain three: Physical classroom</td>
<td>Domain three: Physical classroom</td>
<td>Domain three: Physical classroom</td>
</tr>
<tr>
<td>Domain four: Individual teacher belief</td>
<td>Domain four: Individual teacher belief</td>
<td>Domain four: Individual teacher belief</td>
</tr>
<tr>
<td>Student’s ability to learn (ELL).</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

From examining the tables, it is clear that there are more common factors that hinder implementing a contextualist world view in the elementary mathematics classroom than factors that support this practice. The teachers all mentioned limited time constraint (domain one-school district) to teach the mathematics content along with pressure due to standardized test. All three case study teachers believe that they have to teach instant recall of mathematics facts (domain one-school district) in order for their students to do well on the high-stakes tests. The expectations the case study teachers have for student learning impacted how they approached the learning environment (domain four-
individual teacher belief). Katie and Jenna stated that having a mandated curriculum (domain one-school district) does not allow teachers flexibility in the classroom to teach students based on their individual needs. Katie and Sara both felt unsupported by their peers (domain two-school culture) and limited due to classroom space (domain three-physical classroom). These factors have impeded implementing mathematics instruction from a contextualist world view.

This chapter was divided into three sections: 1) teachers’ beliefs about curriculum, pedagogy and assessment, 2) practice that provides evidence of teacher beliefs, and 3) exploration of relationship between teachers’ beliefs in mathematics and their instructional practice. The first question addresses the case study teachers’ espoused beliefs. All three teachers espouse using a contextualist curriculum in the classroom. In addition, Karen and Sara used curriculum that supports a realist world view. In regard to beliefs about pedagogical practice, all the case study teachers supported a contextualist approach. Jenna, however, also espoused a relativist perspective while Karen and Sara endorse a realist perspective as well. In the area of assessment, all three case study teachers espoused both a contextualist and realist world view.

Question two addresses evidence that provides support for a particular practice implemented in mathematics instruction. Katie and Sara demonstrated consistencies between espoused beliefs and practice, and both teachers exhibited both contextualist and realist practice. However, Katie’s practice resembled more of a contextualist world view while Sara presented a more realist perspective. Jenna presented inconsistency between espoused beliefs and practice. Her practice consisted of mostly realist practice with some examples of contextualist methods. The final section examines the relationship between teachers’ beliefs in mathematics and their instructional practice. The case study teachers

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supported the contextualist world view as an ideal belief, but find factors that support and hinder this practice. Findings based on domain analysis reveal factors that influenced the case study teachers' practice in the mathematics classroom.
CHAPTER 5

DISCUSSION

This chapter is divided into five sections and includes the: 1) summary of the study, 2) discussion of the research findings, 3) limitations of the current study, 4) implications of the current study, and 5) recommendations for further study.

Summary of Study

The study was guided by three research questions:

1. What are teachers’ beliefs about curriculum, pedagogy, and assessment?
2. What practices provide evidence of teacher beliefs about curriculum, pedagogy, and assessment?
3. What is the relationship between teachers’ beliefs about mathematics instruction and their instructional practices?

This study is grounded in a theoretical framework of epistemological world views, specifically the comparison of beliefs across three epistemological world views described by Schraw and Olafson (2002). Three areas of beliefs were addressed in this study: 1) beliefs about curriculum, 2) beliefs about pedagogy, and 3) beliefs about assessment. To extend this framework, this study examined beliefs though the lens of mathematics education. The realist, contextualist, and relativist world views suggest different ways of approaching classroom practice. The goal of the research is to provide a deeper
understanding about the relationship between epistemological world views and teaching practice specific to the domain of mathematics.

Although research has been done to examine the development of students’ epistemological beliefs (Hofer & Pintrich, 1997; Muis, 2004), limited research has examined the development of teachers’ epistemological world views and beliefs. More research is needed to determine how beliefs influence teachers’ instructional practice. Many researchers believe that teacher’s beliefs about teaching and learning does impact their practice (Fennema & Frank, 1992; Ernest, 1988; Thompson, 1984); however, others (Levitt, 2001; Shirk, 1973; White, 2000; Wilcox-Herzog, 2002) believe that there are inconsistencies between teachers’ beliefs and teaching practice. This study attempts to increase understanding of the connection between teachers’ beliefs and teaching practice.

In addition to the research about teacher’s beliefs, there is a growing debate among educators as to how best approach decisions made about curriculum, pedagogy, and assessments in mathematics education. The scope of the current study examines teacher beliefs in mathematics through the world views of realist, contextualist, and relativist. The realist teacher endorses traditional approaches to mathematics that consists of accumulation of facts, rules, and skills to be applied to determine an answer. The contextualist emphasizes curriculum, pedagogy, and assessments that are aligned with the NCTM standards and constructivist practices. The relativist view focuses on each individual child and does not adhere to a particular curriculum. For example, a child that has an interest in music would learn mathematical concepts such as patterning through specific beats to a song. Several curriculum resources are used, but not one textbook provides the basis for instruction. The teacher tailors the environment to best suit each individual child’s needs. This research supported using contextualist approaches to
mathematics instruction where students are engaged in the learning through hands-on lessons. This is also the suggested approach to instruction based on the mathematics reform movement.

Based on the literature shared about traditional mathematics programs and standards-based mathematics programs, there are inconsistent findings about the success of mathematics teaching from either perspective. Some research suggested that traditional mathematics results in higher test scores (Nguyen & Elam, 1993; Nguyen, 1994; Crawford & Rita, 1986; Lafferty, 1994; Alsup & Springler, 2003). This approach to mathematics is supported by the realist world view. The research conducted in traditional mathematics programs has been through quantitative studies. NCTM (1989) standards have influenced decisions about curriculum, teaching, and assessment in mathematics education. This standards-based approach to mathematics is supported by the contextualist and relativist beliefs about curriculum, pedagogy, and assessment.

The research shared in this study that supports a standards-based approach to mathematics showed some support for improved student achievement (Hannafin, 2004; McCaffrey et al., 2001; Carroll, 1996; Carroll, 1997; Mayer, 1998). Based on research, there are also inconsistencies as to how to best approach the mathematics learning environment. The case study research presented in support of the standards-based review did, however, reveal that students who receive instruction in an open-ended, project-based environment developed a conceptual understand of mathematics and were able to apply that meaning through different assessment and situations (Boaler, 1998). This study also supports teachers using contextualist practices in the mathematics classroom.

The design of this study was a qualitative case study. The participants were three 3rd-grade teachers from different schools within the same school district. These teachers
provided the unit of analysis for the study. The schools were selected because they supported a standards-based approach to mathematics mandated per state and district standards. Teachers selected for the study used similar third grade resources to implement standards based mathematics curriculum in the elementary class. In order to understand teachers’ approaches to classroom practice, this study explored the relationship between teachers’ beliefs about mathematics and about mathematics instruction.

Data sources for this study consisted of interviews of teachers, observations of math lessons, and additional documents shared by the teachers. The interview data consisted of three interviews and included a: 1) vignette interview, 2) mid-unit interview, and 3) final interview. In this study, observations of teachers’ mathematics lessons were done through observing a unit of mathematical study within the classroom. The selected document data was used by the researcher to provide support for world views in practice. Domain analysis (Spradley, 1980) revealed findings based on each research question. The researcher used domain analysis because it was the most effective way to organize the data. The interviews, field notes, and document data were categorized around the world views. Domains were constructed based on common themes that emerged from the data sources.

Discussion of Research Findings

Research findings of this study will be discussed in three sections. First, teachers’ beliefs about curriculum, pedagogy, and assessment will be discussed. Second, practice that provides evidence of teachers’ beliefs will be shared. Finally, the relationship between teachers’ beliefs in mathematics and their instructional practices will be examined.
Research Question 1

The first research question of this study sought to understand teachers' beliefs about curriculum, pedagogy, and assessment. All three of the case study teachers utilized a book from the *Investigations* (TERC, 1998) series titled *Landmarks in the Hundreds* (Russell & Rubin, 1998) as part of implementing mathematic instruction. Through these lessons, students engage in inquiry and are asked to construct knowledge as a community of learners. This approach to mathematic is consistent with the contextualist world view. Because each teacher in the study uses this curriculum for teaching the unit on number sense, all of the case study individuals state using a contextualist curriculum. Sara and Katie also espoused supplementing the unit with realist resources.

All three teachers are expected to follow the same curriculum standards and use the same curriculum text as the main resource for implementing the unit of instruction; however, they espoused different pedagogical views. The teachers were given three vignettes, one reflective of each world view, and they were asked questions to gain insight into which perspective they agreed and disagreed with and why. All teachers espoused a contextualist approach to teaching, but variations did exist. The teachers believe that students should work together to construct knowledge. Both Katie and Sara also stated using realist methods of instruction. Katie said she used multiplication recall tests. Sara used *Saxon Math* (Larson, 2004) as her major resource for this mathematic unit while only supplementing with *Investigations*. Jenna endorsed a relativist world view in addition to the contextualist perspective. This means she believes individual students are encouraged to think independently. The focus of instruction is on the individual with little emphasis on peer collaboration.

Each of the case study teachers advocates using both realist and contextualist
approaches to assessment in mathematics. All of the teachers claimed to use classroom observations and questioning of students, which supports the contextualist approach. However, Katie and Sara administer recall tests as a means of the realist assessment. Through contextualist assessments, the teachers feel that they learn about how students learn, but are conflicted because the realist assessments are more consistent with the school district’s grading system. This is why tension exists between the teachers’ beliefs and the pressures to teach in a realist manner. With this being the case, the teachers utilize the realist assessments more for actual grades and focus on contextualist assessment informally. Informally, assessments consist of observations and questioning done by the teacher to gain knowledge of students understanding. These informal assessments are used by the teacher to guide mathematics instruction, but not for determining a letter grade.

So how are these beliefs formed? So many factors impact how a teacher forms beliefs about the most effective way to teach. Because teaching is such a personal profession, what impacts each teacher differs. Many teachers teach the way they were taught. All the teachers reported that their past teachers primarily utilized realist approaches to mathematics instruction. Although realist practices were evidence in some of the observations of the case study teachers, this world view did not prevail throughout all of the lessons. Karen said she had one teacher who made her excited to learn, which is why she approaches the mathematics environment in a positive manner. The teacher still utilized realist methodology, but he explained why certain solutions worked in problem solving. This is why Karen works to exhibit love and excitement for teaching mathematics. By reflecting on teachers’ mathematical history, this impacts their beliefs about how mathematics should be taught.
Research Question 2

The second research question of this study examines the extent to which observations and documents provided evidence of teachers' beliefs in practice. The data analysis, which is a means-end (Spradley, 1980) where characteristics of practice are ways to implement a world view, reveals that all of the case study teachers demonstrate a mixed mathematical practice representative of the contextualist and realist world views. Specific examples from practice were shared to provide evidence of the two domains: 1) realist world view and 2) contextualist world view.

Findings based on domain analysis reveal that two of the case study teachers (Katie and Sara) demonstrate consistencies between espoused beliefs and practice; however, one case study teacher (Jenna) presents an inconsistency between espoused beliefs and practice. Katie indicates that she supports a contextualist and realist world view in curriculum, pedagogy, and assessment. Observation of her practice confirms that she supports these views through mathematics instruction; however, she verbally supports this view more than her practice indicates. Could this mean that she has not transferred this belief fully into practice yet, but she wants to in the future? Sara endorses a realist worldview with some acceptance of the contextualist perspective, which corresponds directly to her mathematics practice in the classroom. Conversely, Jenna espouses using a contextualist curriculum through pedagogical methods that support both a contextualist and relativist approach to learning, while utilizing assessments that exhibit a contextualist and realist world view. The only stated consistency in all three areas of curriculum, pedagogy, and assessment support a contextualist framework. Based on her practice, Jenna demonstrates a mostly realist practice with some examples of contextualist methods.
How does a teacher take her espoused beliefs and transfer that into the mathematics classroom? Karen and Sara were better able to articulate how they approach instruction in the classroom. Teachers need to be able to understand how what they say transfers into what they do in classroom practice. Without make these connections, teachers will not be able to achieve effective practice in mathematics.

Perhaps Jenna is working toward making a shift in her thinking. She espouses more contextualist views than what is documented in her teaching. First, teachers need to be able to articulate their beliefs before actualizing them into practice. To create change in Jenna, she needs to realize how her practice does not align with what she stated she believes. By observing dissonance between her belief and practice, this provides an opportunity for growth. After watching her mid-unit interview, she called herself a hypocrite because what she stated did not correspond to her practice. This might make her think about how she teaches and produce a change in her practice.

By reflecting on her practice, Jenna was able to learn about her own approaches to teaching. Having teachers watch videos of themselves will allow them the opportunity to determine if their beliefs are consistent with their practice. Sherin (2000) found similar results by doing research with teachers through video club. The teachers were able to investigate their teaching practice and better understand what was happening in their classrooms. One finding from this study suggests that reflection allows teachers to examine their beliefs in connection with practice. The next section will address why these case study teachers have consistencies and inconsistencies between their espoused beliefs and actual practice.
The third research question explores the relationship between teachers’ beliefs in mathematics and their instructional practices. Ideal beliefs differ from espoused beliefs because an ideal belief is how a teacher truly believes mathematics should be taught; whereas, espoused beliefs are how the teacher sees herself implementing curriculum, pedagogy, and assessments. The tension exists based on constraints in the teaching environment. These constraints influence how the teachers approached teaching the mathematics content and impact their pedagogical approaches, which makes the teachers resort to realist strategies. Although the teachers want to teach from a contextualist perspective, the nebulous pressures overcome their ideal beliefs. This research question addresses factors that influence practice based on the case study teachers’ ideal beliefs. Analysis of mid- and final interviews during Phase II provide evidence of the teachers’ ideal beliefs and factors that impact practice.

Findings based on domain analysis reveal factors that influence the case study teachers’ practice in the mathematics classroom. The following domains were examined based on the data (Table 16): 1) domain one: school district factors, 2) domain two: school culture factors, 3) domain three: physical classroom factors, and 4) domain four: individual teacher factors. All of the case study teachers expressed needing more time with the students to develop mathematical concepts (domain two-school culture). Having the school support (domain two-school culture) to implement the contextual world views through school goals and/or curriculum textbooks was another factor that all three teachers addressed. Katie and Jenna both found it important to have access to hands-on materials (domain two-school culture) so that student can construct knowledge through problem solving situations (domain four-individual teacher belief).

There are more common factors that hinder implementing a contextualist world view
in the elementary mathematics classroom than factors that support this practice (Table 17). The teachers all mentioned limited time constraints (domain one-school district) to teach the mathematics content, along with pressure to do well on standardized tests. All three case study teachers believe that they have to teach instant recall of mathematics facts (domain one-school district) in order for their students to do well on the high-stakes tests. The expectations the case study teachers have for student learning impacted how they approached the learning environment (domain four-individual teacher belief). Katie and Jenna stated that having a mandated curriculum (domain one-school district) does not give teachers flexibility in the classroom to teach students based on their individual needs. Katie and Sara both felt unsupported by their peers (domain two-school culture) and limited due to classroom space (domain three-physical classroom). These factors have impeded implementing mathematics instruction from a contextualist world view.

Why do teachers’ beliefs not always transfer into the learning environment? There is no clear-cut answer to this question. Several factors impact why a teacher approaches mathematics in a particular manner. Having a set of beliefs is only part of what effects teaching. Based on the factors shared in the domain analysis, teachers approach instruction differently, given their individual constraints and support. When the teachers start to feel pressure, they revert back to realist practice. This could be because that was the way they were taught or because that is what they are most comfortable with or because it is supported by administration, peers, and/or other authority figures. Because each individual teacher is different, what affects his or her teaching varies. Most teacher education courses support a contextualist world view, which may be why all the case study individuals embraced this perspective. More support for contextualist practice need to be given to teachers so that they can teach in the ways they believe to be most
effective. The teachers need to make the connection between practice and theoretical world views. The contextualist world view coincides with the mathematics standards-based movement. The findings from this study support the contextualist approach to mathematics instruction.

Conclusion

Why is it important to examine teachers' espoused beliefs? If a teacher is able to articulate their beliefs, can these beliefs be observed in practice? According to this research, the teachers who were able to give clear examples of world views as part of their practice are more consistent with these world views in their practice. For example, Katie articulates specific lessons where students are using manipulatives to construct knowledge of multiplication, which supports the contextualist world view. Through observation data, the researcher was able to verify that hands-on learning was used in classroom practice. The students used cubes to determine factors for the numbers 24, 36, and 48. Conversely, Jenna was not able to give specific examples of the relativist practice in the mathematics classroom; however, this is the world view she stated that she most strongly endorses. The relativist perspective focuses on specific instruction suited for each individual child. All of Jenna's lessons were whole group, although there were attempts made by the teacher to help individual students with the whole group task. Sara was able to articulate her beliefs and give specific examples of practice. Most of her examples were reflective of a realist world view. Mathematics practices that support the realist world view were most evidence from observations in her classroom. This suggests that teachers who can describe specific strategies or methodologies used in their teaching are more consistent in their actual practice meaning that teachers understand how beliefs transfer into practice.
All three of the case study teachers were selected for this study because they stated implementing similar curriculum. They all utilized *Investigations* (TERC, 1998), a contextualist curriculum resource, but implemented this curriculum in different ways. Through data analysis, the researcher determined that all of the teachers implemented a combination of the contextualist and realist world view to varying degrees in practice. If this research study was conducted with teachers who implemented more traditional curriculum resources that support a realist perspective such as *Saxon Math* (Larson, 2004), would difference in practice occur? The assumption is that the schools in which teachers implemented *Saxon Math* or other traditional textbooks would be found to have more teachers demonstrating realist instructional practices. Furthermore, private school and/or Gifted and Talented Education (GATE) classes may be found having teachers using relativist approaches to learning. This could be because curriculum restrictions are not mandated in these environments. What if different grade levels were examined? Perhaps in more immediate grades, the researcher would find that the teachers become more realist in practice because of the difficulty of the mathematics content. It is more acceptable for teachers to provide manipulatives and cooperative learning, which is reflective of the contextualist world view in the younger grades. Further research is needed to confirm these assumptions.

Sara stated using both *Saxon Math* and *Investigations*, but relied more heavily on *Saxon Math* for teaching the unit. It is not surprising to find that Sara exhibited more realist practices in her instruction than the other two case study individuals. This implies that the curriculum utilized by the teacher mandates, to some degree, the pedagogical approaches to instructions. In Sara’s case, the school favored using *Saxon Math* as the basis for mathematics instruction, which is a factor that influences why Sara approaches
to teaching mirror the realist world view. The contextualist curriculum resource, *Investigations*, also impacted how the case study teachers approached assessment in mathematics.

Assessments implemented from a contextualist world view were difficult to equate to a letter grade for both Katie and Jenna. They found contextualist assessment useful for providing future instruction and for re-teaching concepts, but hard to assign a letter grade for report cards. Does this means standardized tests and report cards with assigned letter grades may not give students and/or parents specific information about how a child learns? Sara used *Investigations*’ teacher checkpoints as a way to grade students, although the text specifically states that these tasks are an informal way for teachers to check for students understanding. Sara clearly misunderstands how *Investigations* structures assessment, and furthermore, she is not able to elaborate as to how she equates these checkpoints into a letter grade. This demonstrates a tension between how teachers are required to grade student learning as opposed to how they collect information to understand how students learn mathematical concepts.

Another aspect of the study, found that four domains supported and/or hindered the teachers in implementing the contextualist world view. These domains include: 1) domain one: school district factors, 2) domain two: school culture factors, 3) domain three: physical classroom factors, and 4) domain four: individual teacher factors. Domain one, school district factors, were mentioned the most by all of the case study individual as aspects that supported and hindered instruction. Does this mean that mandates and directives based on legislation impact the learning environment more than any other factors? If so, it would imply that broad external factors impact the classroom more than site base decision made by principals and teachers.
Doing some survey research and having teachers rank factors in order of importance would provide more information as to which factors most impact each teacher. Because of individual differences, it is difficult to claim that one factor and/or domain affects the teachers more than the others. The teachers in this study all cited school district factors more than other domains. This means, that school districts need to provide more support for math educators to provide hands-on learning. Mathematics teachers also need to understand how the contextualist world view is translated into practice. If the teacher’s beliefs are solidified, the chances of transferring the world views into instruction are greater. Most of the hindrances to implementing contextualist practice were sited as school district decisions. These teachers felt that the school district does not support contextualist practices even though all the teachers believe these are the most effective strategies to produce student learning.

The teachers cited the students’ ability to learn, which is an individual teacher belief (domain four), that is viewed as a hindrance to implementing contextualist mathematics practices. Many factors from the school district negatively impacted teachers, but the only other domain mentioned was individual teacher belief. The expectations that the teachers have of their students impact how they approach the learning environment. Katie and Sara mentioned school culture (domain two) and the physical classroom (domain three) as factors for not teaching from a contextualist perspective. They did not feel supported by their peers nor did they have enough space in their classroom. However, Katie did say that other teachers in her school were interested in how she approached mathematics instruction. Perhaps this is why Katie’s teaching is more reflective of the contextualist world view than Sara.

In terms of support for contextualist mathematics world view, Katie and Jenna listed
individual teacher beliefs (domain four) as the most important factors. This is important because Katie and Jenna were the ones who implemented the contextualist approach more often in their mathematics instruction. These two teachers view support for contextualist approaches most heavily coming from their own beliefs about how students learn. This implies that if a teacher’s has strong beliefs about curriculum, pedagogy, and assessment, he or she will overcome any barrier to implementation. Katie and Jenna list school culture (domain two) as ways contextualist practices are supported in their classroom. Things such as school goals and access to materials were instrumental in teaching through hands-on methods. Sara did also mention that problem solving is a school goal, which does show support for multiple approaches to learning through a community environment. Katie and Jenna were able to list many more factors that lend support for teaching in a contextualist fashion. With more levels of support, the teachers are able to implement mathematics instruction in ways that are concurrent with their beliefs. Other researchers have confirmed the importance of support when implementing mathematics reform practices (Hernandez & Brendefur, 2003; Schoen, Cebulla, Finn, & Fi, 2003). Remillard and Bryans (2004) found that teachers needed opportunities for learning of the standard-based curriculum materials to be successful with mathematics instruction. Without support for implementing Investigations, the impact of these curriculum materials is unpredictable and varied. The next section will address limitations of the current study.

Limitations

All studies have limitations, and this study is no exception. Limitations of this study are discussed in sections: participants and settings, research findings, and researcher bias.
Participants and Setting

One limitation of this study centers on participants and setting. First, the setting of this study consisted of three different schools in an extremely large school district. The selection of the schools was based on the schools involvement in professional development offered in mathematics education by a National Science Foundation (NSF) grant. The involvement of the schools and teachers in the grant varied among the schools. Second, the teachers were selected because they all utilized the Investigations (TERC, 1998) series, specifically the textbook Landmarks in the Hundreds (Russell & Rubin, 1998), for implementing the unit on number sense. Third, the selected grade level was chosen because of the researcher’s knowledge of the mathematics curriculum for third grade. It is probable that other teachers selected from different schools and/or varying grade levels might yield different result from this study.

Research Findings

Research findings of this study are limited by several factors. The number of participants in this study was not extensive and as a result, findings may not be transferable to larger populations. The focus of the world views were limited due to only addressing: 1) beliefs about curriculum, 2) beliefs about pedagogy, and 3) beliefs about assessment. Schraw and Olafson (2002) have six additional beliefs that embody epistemological world views: assumptions about knowledge, reality and truth, the constructivist process, and the role of the teacher, students, and peers. The three areas chosen for the current study were of most important because it provided a complete view of how mathematics instruction is implemented. The researcher also wanted to focus more deeply on teacher beliefs in specific areas as opposed to more of a narrow focus in multiple areas. Hence, the qualitative nature of the study allowed for in-depth analysis.
The focus of this study was qualitative and lacked any quantitative instrument to measure teachers' beliefs. The purpose of qualitative research is to give a rich narrative account of the data (Merriam, 1998). Research findings of this study are not necessarily conclusive, which should be considered when contemplating these results and findings.

Researcher Bias

In conducting this research, it is difficult to remove bias from the researcher’s perspective. The researcher conducting this study is an experienced teacher and a doctoral student in curriculum and instruction with an emphasis in teacher education. The researcher pursued a study that involved teacher education with a focus on mathematics education because that is an area in which she is knowledgeable. Although all observations were descriptive, interactions with teachers, both informally and during focused interviews, may have impacted the interpretation of the results.

The research accounted for bias through triangulation, which means to consider a process of using multiple perspectives to clarify meaning, verifying the repeatability of an observation or interpretation (Stake, 2003). This was accomplished through analyzing interviews, observations, and documentation data. The researcher sought to find agreement throughout the data sources to provide the study with validity. Although, no observations or interpretations are repeatable identically, triangulation assists in clarifying means through different data sources (Stake, 2003). The researcher also conducted member check which means taking data and interpretations back to the people from whom they were derived and asking them if the result were reasonable (Merriam, 1998). Copies of transcription and written chapters were provided to all case study individuals to verify internal validity.
Implications

Several implications have resulted from this study that impact the ways we prepare teachers in mathematics methods courses and mathematics professional development of teachers. It is important that teachers have an understanding of mathematics content and an understanding of beliefs. Part of understanding these beliefs involves the relationship of these beliefs to classroom experiences. When teachers can articulate their beliefs clearly and give examples of how these beliefs impact classroom practice, there is more transfer into pedagogical instruction. Courses for pre-service teachers and teachers should incorporate a comparison of world views into coursework. This could be achieved by watching different lessons of teachers implementing mathematics content to determine which world view is evident. Also, teachers/pre-service teachers should try analyzing their own mathematics lessons with respect to the world views. Through reflection, teachers gain knowledge about the ways they implement instruction in the mathematics classroom. The teachers must develop an understanding of world views and how that relates to practice instead of the “make it take it” workshop format that is prevalent in teacher education. The theoretical framework of world views needs to be explicitly connected to classroom practice. Different teaching scenarios need to be examined by the teachers to determine why it is reflective of a particular world view. Coursework would involve more discussion about world views and specific examples of practice. This would require teacher education programs to incorporate more field-based instruction, and collaboration between the university and school district.

The school district in which the study was conducted supports a realist world view of curriculum and assessment. Conversely, the university and professional development courses that these teachers were exposed to support a contextualist approach to
curriculum and assessment. This tension sends mixed messages to teachers in the elementary mathematics classroom. The theoretical framework of world views needs to be explicitly connected to classroom practice. This might entail a teacher education program that incorporates more field-based instruction and collaboration between the university and school district. By supporting collaborative efforts between teacher educators and school districts, a shared vision for world views could be achieved to minimize pressure for the teachers caught in-between two extremes of opposing world views. The goal for a shared world view needs to be supported by the schools within the larger district.

The solution to these opposing views of the realist and contextualist is to compromise. In an ideal world, the goal would be for teachers to implement contextualist approaches to instruction while still adhering to realist forms of assessment. If students are able to construct meaning of mathematics through hands-on experiences, this knowledge should transfer to recall forms of assessment, which are required by school districts nationwide. By drilling students to learn mathematics facts and repeating recall tests, educators are not building conceptual knowledge of mathematics. Once this knowledge is built through inquiry-based lessons, then recall testing at the end of the year should not pose a problem for teachers and/or students. Thus, this would meet requirements of school district and teacher educators.

This study also helps to inform the mathematics domain in regards to the world views. Research involving world views has been done from a global educational perspective with little focus on domain specific areas such as mathematics education. The emphasis on instant recall of mathematics facts was important to all the teachers in the study, which is primary in the realist perspective. However, all teachers stated that
teaching through contextualist methods is most effective for student learning. This creates
a tension of how to approach the learning environment in the mathematics classroom.
Having knowledge of world views as it relates to mathematics is limited for the teachers
in the study. Again, more focus on the theoretical perspectives supporting these world
views can help teachers translate these beliefs into mathematical practice, thus creating
more effective mathematics instructors.

Future Research

Recommendations for further study in this area include replicating the methodology
of this study as it relates to different content domains such as: literacy, science, and/or
social studies. Currently, there are limited studies that focus on teacher beliefs in content
specific areas (Johnston, et al. 2001; Levitt, 2001). It is important to determine if teachers
approach curriculum, pedagogy, and assessment differently given the specific content
area. If a teacher implements contextualist approaches to learning mathematics, would the
same be found for the teacher’s instruction in regard to literacy? Do beliefs that form
world views remain constant for teachers throughout all domains or are there differences
given the content? This question remains unanswered.

The current study found that teachers’ believe that teaching and learning of
mathematics should be from a contextualist perspective; however, all the case study
teachers still use realist strategies. This is consistent with what was found by Levitt
(2001) in her study that examined the beliefs of elementary teachers in regards to science
education. Gaps in the research between the teachers’ beliefs and the mathematics reform
still exist; however, this study suggests that there is a movement towards the suggested
mathematics reform because all the teachers espoused wanting to teach mathematics from
a contextualist perspective. From this study, it was determined that not all espoused beliefs are translated into classroom practice due to factors that hinder contextualist approaches, but support the realist perspective. The four domains that addressed these factors included: 1) domain one: school district factors, 2) domain two: school culture factors, 3) domain three: physical classroom factors, and 4) domain four: individual teacher factors.

More studies are needed in mathematics education in regards to world views. Studies that incorporate both qualitative and quantitative methodologies would be advantageous to the field of mathematic education. In addition to this study, the Standards Belief Instrument (SBI) could assess teacher beliefs about the NCTM Standards using items representative of beliefs underlying the Standards (Zollman & Mason, 1992). The purpose of the SBI is to measure teachers' beliefs underlying the standards, rather than assess comprehensive knowledge of specific aspects of the standards. This would provide a more focused study on standard-based curriculum.

This study could also be replicated by focusing on other beliefs about the world views (Schraw & Olafson, 2002): assumptions about knowledge, reality and truth, the constructivist process, and the role of the teacher, students, and peers. A similar study could be designed to examine different beliefs within each of the worldviews: 1) realist, 2) contextualist, and 3) relativist. Again, studies could focus on a domain-specific area such as mathematics education or examine the world view perspective of the teacher about the whole of education. Studies need to be conducted at both the elementary and secondary level. Domain specific studies are generally conducted at the secondary level due to teacher expertise in the given domain. This creates more of a need for studies conducted in the elementary level for a specific domain.
Future research should also focus on understanding how epistemological world views change and develop in mathematics. Few studies have examined how teachers' epistemological world views and beliefs develop (Calderhead, 1996; Patrick & Pintrich 2001). This research found no studies that examine how teachers' epistemological world views and beliefs develop in regards to mathematics education. By examining how epistemological beliefs and world views change, the researcher needs to consider the teacher's past experience as a student through the role of becoming a teacher. Through considering these changes, the researcher can determine how this affects the teacher's classroom instruction. This is a new area of research that needs much attention.

Finally, the impact of teachers' epistemological world views should be examined in respect to students' beliefs. Also, research should be conducted to determine teachers' beliefs and their instructional style. Is there a relationship between teachers' beliefs and students' performance? How can teachers' beliefs impact students' beliefs and achievement? Again, these questions can be considered through the domain of mathematics education. These are questions that need answers through continued research in epistemology.

In order to produce effective teachers of mathematics education, it is imperative to examine world views. Not only should teachers understand world views, but also a concerted effort needs to be made to produce contextualist teachers through teacher preparation courses. Specifically, the instructional implications of this research suggest that teachers should engage students in actively learning mathematics using a contextualist world view approach to teaching mathematics. Too often, mathematics instruction amounts to the recall of algorithms without emphasis on problem solving and conceptual development. The reform movement led by the NCTM standards needs to be a
guide for teacher educator when considering the design of mathematics methods classes for teachers.
TITLE OF STUDY: Exploring the relationship between teachers’ beliefs in mathematics and their instructional practice

INVESTIGATOR(S): Jeff Shih, Ph. D. and Michelle Vander Veldt

College of Education - Department of Curriculum and Instruction
4505 Maryland Parkway Box 453005
Las Vegas, Nevada 89154-3005

CONTACT PHONE NUMBER: Dr. Shih 895-4984 and Michelle 895-4670

Purpose of the Study
You are invited to participate in a research study. The purpose of this study is to examine the relationship between teachers’ beliefs in mathematics and instructional practice.

Participants
You are being asked to participate in the study because you have participated in a prior study involving mathematics professional development.

Procedures
If you volunteer to participate in this study, you will be asked to do the following:

1. Answer interview questions to determine your beliefs about teaching and mathematics education.
2. Reflect upon teaching through interviews.
3. To be observed during your mathematics instruction.
4. Agree to be audio taped during interviews and observations.

Benefits of Participation
By participating, you will have the opportunity to discuss your personal beliefs about teaching, your beliefs about mathematics and student learning. Gaining this information will contribute to research in education and may help future teachers enhance their mathematics skills and knowledge in increasing student learning.

Risks of Participation
There are risks involved in all research studies. This study may include only minimal risks. You may be uncomfortable answering some of the questions asked during the
interviews. However, you are encouraged to discuss this with me.

**Cost /Compensation**
There will not be financial cost to you to participate in this study. The study will take about 60 minutes a day during 5-6 visits over a period of 6-8 weeks. You will not be compensated for your time. *The University of Nevada, Las Vegas may not provide compensation or free medical care for an unanticipated injury sustained as a result of participating in this research study.*

**Contact Information**
If you have any questions or concerns about the study, you may contact either Dr. Jeff Shih at 895-4684 or Michelle Vander Veldt at 895-4670. For questions regarding the rights of research subjects, any complaints or comments regarding the manner in which the study is being conducted you may contact the UNLV Office for the Protection of Research Subjects at 702-895-2794.

**Voluntary Participation**
Your participation in this study is voluntary. You may refuse to participate in this study or in any part of this study. You may withdraw at any time without prejudice to your relations with the university. You are encouraged to ask questions about this study at the beginning or any time during the research study.

**Confidentiality**
All information gathered in this study will be kept completely confidential. No reference will be made in written or oral materials that could link you to this study. All records will be stored in a locked facility at UNLV for at least 3 years after completion of the study. After the storage time the information gathered will be shredded.

**Participant Consent:**
I have read the above information and agree to participate in this study. I am at least 18 years of age. A copy of this form has been given to me.
I agree to allow interviews and observation to be audio taped. ___ Yes ___ No

____________________________  __________________________
Signature of Participant        Date

____________________________
Participant Name (Please Print)

*Participant Note: Please do not sign this document if the Approval Stamp is missing or is expired.*
APPENDIX B
Letter of Acknowledgement of a Research Project at a CCSD Facility

Brenda Durosinmi, MPA, CIP, CIM -Director
Office for the Protection of Research Subjects
University of Nevada Las Vegas
4505 Maryland Parkway Box 451037
Las Vegas, NV 89154-1037

Subject: Letter of Acknowledgement of a Research Project at a CCSD Facility

Dear Ms. Durosinmi:

This letter will acknowledge that I have reviewed a request by Dr. Jeff Shih and Michelle Vander Veldt to conduct a research project entitled, “Exploring the relationship between teachers’ beliefs in mathematics and their instructional practice at [facility name/s and location/s].

When the research project has received approval from the UNLV Institutional Review Board and the Department of Research and Accountability of the Clark County School District, and upon presentation of the approval letter to me by the approved researcher, as site administrator for [facility name] I agree to accept liability for the approved research project.

If we have any concerns or need additional information, the project researcher will be contacted or we will contact the UNLV Office for the Protection of Research Subjects at 895 - 2794.

Sincerely,

Authorized Facility Representative Signature Date

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APPENDIX C

Pre-Unit Interview

Initial Formal Interview Protocol (MATHEMATICS)

Script: Hello, I’m Michelle and I am doing MASE research. For this interview, I will be asking you a series of questions concerning your planning and general ideas about teaching mathematics. Please relax and respond to the question to the best of your ability.

Teacher’s Name: 
Interviewer: 
Date: Beginning Time: Ending Time: 
Beginning Time: Ending Time: 
Venue: 
Grade: 3 
Unit: Landmarks in the Hundreds

BACKGROUND

1. The unit that you’ll be videotaped will be Landmarks in the Hundreds. Have you taught this topic/unit before? 
   How did you teach it before? 
   What are some of the specific changes that you’ve made in teaching this unit over the years? 
   Why did you make these changes? 
   Do you think you will make any changes in teaching the unit this time?

UNIT

1. Briefly describe how you will teach this unit? 
   In planning the unit, what will be/were some of the easiest and challenging aspects of teaching it?

2. How many lessons do you think you will need to teach this unit, in hours or days and why? 
   On average, how long would one typical lesson be?

3. What are the goals or objectives of the unit? 
   How did you come up with those objectives? 
   And why do you think students need to learn the unit?
4. What materials do you plan to use in your unit? Please explain what these materials will offer? Why did you decide to use these materials?

5. How would you describe your students? What are they like? What about their background? How do you think they learn math? What are their general attitudes toward math learning?

6. What do you consider to be the most important concepts that your students need to understand for this unit?

7. What modes of instruction are most effective in learning these important concepts? What will your students be doing during lessons?

8. What do you anticipate to be the difficult concepts that your students will struggle with? Why do you think this would be the case? So how will you teach these difficult concepts?

9. How would you describe your role in your student’s learning and why?

10. How will you be assessing your students’ understanding of the major concepts in the unit? Why do you want to assess in this/these way(s)?

11. What influences, if any, do you think your school environment and/or community have on your students’ learning in this unit?

12. If you were in an ideal situation without any limitations on anything, what would you like to change in designing and teaching this unit? Please describe. What currently prevents you from doing this?

INFLUENCE

1. Did you talk with anyone about teaching this unit? A colleague? Administrator? Project facilitator? What influences, if any, have these interactions had on your ideas in the development or teaching of this unit?

2. Thinking back to your professional development experiences, what are your general views about the professional development activities that you attended? What would you consider to be the major goals of the workshops? What, if any, do you consider to be the most important thing that you learned from the workshops?
3. In general, to what extent did the professional development activities influence your ideas on mathematics teaching and learning? Can you describe some of the most memorable events that you experienced in the workshops?

4. Do you think any of the professional development activities directly influenced your preparation and development of the unit in any way? Can you please describe any of these specific professional development activities in detail? How did they specifically impact your preparation and/or development?

5. For um, what additional support for your teaching did you receive from the MASE and/or SMT project? For instance, did a facilitator go visit you in your classroom or did you receive extra assistance in addition to attending the workshops. Please describe these additional support experiences. Did any of these experiences change your thinking, preparation or teaching in any way?

6. For our project, may we please have a copy of your unit plan and any additional materials that you will be using in your teaching?

7. Are there any issues/concerns/issues that you would like to discuss about our interview and/or project?

Thanks for taking the time to answer these questions. We appreciate your participation in this project.

Interview Ending Time:
APPENDIX D

Formal MID-INTERVIEW Protocol (MATHEMATICS)

Script: For this interview, I will once again be asking you a series of questions concerning your background, views about how your unit is coming along, and general ideas about teaching and learning. Please relax and respond to the question to the best of your ability.

Teacher’s Name: _______________________________________
Interviewer: ____________________________________________
Date: _______________ Beginning Time: _______________ Ending Time: _______________
Place: _________________________________________________
Grade: _______________
Unit: _________________________________________________

BACKGROUND

1. Why did you become a teacher? What keeps you continuing on in teaching?

2. What is your educational background including degrees, majors, and teacher education preparation?

3. How long have you been teaching? Which grade levels have you taught? How many years experience do you have in teaching the grade level that you’re currently teaching?

4. How do you view the importance of mathematics compared to other subject areas at the elementary level? Why? (Probe for their view of the nature of mathematics)

5. How do you think the majority of your students learn mathematics? What is your most favorite way to teach mathematics? (View of mathematics learning and teaching)

6. Have your views of mathematics, mathematics learning, and teaching changed over time? If so, what are the changes?

6. Can you describe your preparation in teaching mathematics during the major stages of your education? How did your mathematics education received in these stages contribute to your teaching mathematics generally? How did the education contribute to your learning of mathematics content for the specific grade level and unit that you are currently teaching? Explain.
UNIT ASSESSMENT

8. How is the unit coming along at this moment? What were some of your major goals for your students to learn in this unit? Do you think your students are meeting the goals and objectives that you’ve planned so far? Explain.

9. Please describe what concepts your students easily grasped and what concepts your students are struggling to learn. How do you know this? (Probe to find out how they came up with these assessments of student learning)

10. Can you describe and explain any surprises that you’ve encountered during your teaching of this unit so far? Why? Did you encounter any barriers/problems in teaching this unit? Explain what they are, if any.

11. Did any of your original teaching plans (e.g., teaching strategies or time schedule) change? Why or why not?

INFLUENCES

12. What influences, if any, do you think your school environment and/or community have on your students’ learning or your teaching in this unit so far (Probing details)?

13. Do you think that your students have influenced the way you’ve taught or planned for this unit so far? Explain how (Probing details).

14. If you were able to teach this unit in an ideal situation, what would it look like? (Describe and explain the environment, community, and students.)

15. Which aspects, if any, and to what extent have these ideas been impacted by your professional development (MASE and SMT) experiences?

16. In teaching the unit, have you ever felt that the lack of resources or support (from other teachers in your school, principal, curricular materials, etc) affected how well you are teaching this unit? Why or why not?

17. At any time during the teaching of this unit so far, have you thought about anything that you’ve learned or experienced from the professional development sessions? Why or why not? (Probing the details of the workshop and the lesson)

18. Are there any issues/concerns/issues that you would like to discuss regarding your teaching, our interviews, and/or project?

Thanks for taking the time to answer these questions. We really appreciate your participation in this project.

Interview Ending Time: ____________
APPENDIX E

Formal FINAL INTERVIEW Protocol (MATHEMATICS)

Script: For this final interview, I will be asking you a series of questions concerning your views about the unit and your overall ideas about teaching and learning. Again, as in all of our previous interviews, please relax and respond to the question to the best of your ability.

Teacher's Name: _______________________________________
Interviewer: ____________________________________________

Date: _______________ Beginning Time: _______________ Ending Time: _______________
Venue: _____________________________________________
Grade: __________________________
Unit: ________________________________________________

BACKGROUND

1. Please compare your best and worst lesson in the unit. Why do you consider these lessons to be the best or worst? (Probe for teacher's role and student actions)

2. Please describe what effective or good mathematics teaching look like. (Probe for teacher's role, students' roles or actions)

UNIT ASSESSMENT

1. What were some of your major goals for the unit? Did you meet these goals? Explain why or why not.

2. In this unit, what were some of the easiest and challenging aspects of planning and teaching it? Please explain in detail. Please describe and explain any surprises that you’ve discovered while teaching this unit.

3. How do you view your students’ learning in this unit (in general and specific terms)? Did they grasp the concepts easily or had some difficulties? How do you know?

4. What do you consider to be the most important concepts that your students learned during this unit? Why were these important to learn?

5. How do you know whether students learned these concepts or not? Please
6. describe the assessment strategies. Did these assessment strategies deviate from the original plan? Explain.

6. What were your students’ general attitudes towards mathematics/science learning during this unit?

7. What teaching strategies did you use during the unit? When did you use those strategies? Did any of these strategies deviate from your original plan? 
   If no, go to next question.
   If yes, why did these changes occur?

8. What curricular materials did you predominantly use? What did you like and dislike about the materials? What supplemental materials did you use? Did you make any changes or modifications for your initial plan in using the curriculum materials? Why?

9. If you were going to teach this unit again, what changes, if any, would you make? (Make sure to ask about any changes in content or concepts, strategies, activities, curricular materials, lesson sequence, etc.) Please describe in detail and explain why you would make or not make these changes?

10. What influences, if any, do you think your school environment and/or community had on your students’ learning in this unit?
    If nothing, go to next question.
    If something, please explain and describe and provide details.

11. If you were in an ideal situation without any limitation on anything, what would you like to change in teaching this unit? What resources or sources for support would you request? (e.g., district specialist consultant, workshops, curricular materials, etc) Please describe.
    If nothing, go to next question.
    If something, please explain and describe and provide details.

12. What major barriers/problems, if any, did you faced while teaching this unit?

INFLUENCE

1. When did you plan most of the lessons? What do you consider when you plan lessons? (Make sure that you probe for any evidence of teachers’ reflection on teaching).

2. How do you think teacher develop their skills and knowledge?

3. Do you have any recommendations to the district or other professional development institutions such as universities to help you develop better skills in mathematics teaching? Please describe in detail and provide examples from you past experience.

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4. How would you define good professional development?

5. Overall, to what extent did the professional development activities/sessions influence your ideas on mathematics teaching and learning? Can you describe and provide an example of a direct impact to your preparations and teaching of this unit? (Attempt to probe for any significant experiences)

6. What does inquiry mean to you? How would you describe an inquiry lesson? Did you incorporate inquiry into your lessons/unit? If so, how often do you think you incorporate inquiry into your lessons and please describe one of the inquiry lessons?

7. How much influence did the video-taping impact your teaching? If you were going to re-teach this unit without the video-taping, what changes to your teaching and/or planning and/or materials would you make? Why?

8. Are there any issues/concerns/issues that you would like to discuss about our interviews and/or project?

Thanks for taking the time to answer these questions. You've provided us with some very useful and valuable information throughout this unit. We greatly appreciate your participation in this project.

Interview Ending Time:__________________
APPENDIX F

Phase II – Interview 1
Vignettes
(Schraw & Olafson, 2002)

Provide the participant with copies of the three vignettes of teaching (realist, contextualist, and relativist) and ask the following questions:

With which viewpoint did you most strongly agree with?
- What statements in the vignette did you most strongly identify with?
- Discuss specific examples in your classroom that are consistent with this viewpoint.

With which viewpoint did you most strongly disagree with?
- What statements in the vignette did you most strongly disagree with?
APPENDIX G

A Summary of Three Epistemological Worldviews

Realist Worldview (Vignette 1)

There is a core body of knowledge in my classroom that each student must learn. Some of it is factual, but some of it is based on broad concepts and principles that everyone agrees on. This knowledge doesn’t change much over time and represents the accumulation of important truths and understanding in my discipline. It’s important for students to acquire this knowledge exactly as it is. The best way to acquire this knowledge is through an expert like me because I have a much better sense than they do of what is important to learn. It’s unlikely that students could really create this knowledge on their own, so learning it from me quicker and more efficient. For this reason, it is important to me to assume a take-charge attitude so students can learn as much as possible. It’s important to me that everyone comes away from my class with the big picture. It is my job to present the big picture clearly.

Contextualist Worldview (Vignette 2)

Students are encouraged to develop their own understanding in my classroom so knowledge is personally useful to them. However, the fact that students are expected to construct their own understanding doesn’t mean that all understandings are equally valid. While I believe that knowledge is subject to interpretation, I also believe that some conclusions are better than others. Students need to understand how to gather and
evaluate evidence so they can distinguish good from poor arguments. I can teach them some of these skills, but some they will have to learn by working with other students, or on their own. I believe that each student will bring a unique and valuable perspective with them. I try to structure my class so that students will pool their resources and come to the best understanding possible.

Relativist Worldview (Vignette 3)

Students in my class need to understand that there are a variety of different ways to understand things. Knowledge comes and goes, and what the so-called experts consider the truth today will be viewed with suspicion tomorrow. Even people who spend years studying a topic disagree about what things mean, and in the long run, one opinion is as good as another. This means that students have to learn to think for themselves, question the knowledge and authority of others, and evaluate how what they know affects their life. Knowledge has to be used wisely so no one is left out or exploited by society. For these reasons, I don’t believe that I can really teach my students what is important, since they all need to know different things. They have to figure it out on their own, taking into account the events that shape their lives, even if the uncertainty of living in a world with conflicting views of truth bothers them. What I know and believe shouldn’t really influence my students. My job is to create an environment where students can learn to think independently and take nothing for granted.
APPENDIX H

Interviews 2 and 3

Videotape Reflection and Final Interview Prompts

- Tell me about your practice.
- How does your practice relate to your worldview?
- Is your practice consistent with your worldview? Why or why not?
- Discuss the relationship between beliefs and practice.
- What would help you teach in the ways you want to teach?
- What hinders you from teaching in the ways you want to teach?
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