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EXAMINING ROBERTS COUNTY MATHEMATICS TEACHERS' BELIEFS REGARDING THE NATURE OF MATHEMATICS AND THEIR CLASSROOM LEARNING ENVIRONMENT

by

ELIZABETH P. BRECHIN-HARRISON

(Under the Direction of Gregory Chamblee)

ABSTRACT

The purpose of this study was to examine the relationship of mathematics teachers' beliefs regarding the nature of mathematics and their classroom learning environment in Roberts County. The study investigated 165 kindergarten through twelfth grade mathematics teachers that taught at least one segment of mathematics a day. The researcher administered three surveys: the *Teacher Beliefs Survey* (developed by Beswick, 2005), the *Constructivist Learning Environment Survey* (developed by Taylor, Fraser, and Fisher, 1997) and a demographics survey to mathematics teachers at 35 schools. Data analysis included calculating the sub-scale means of each survey, a Pearson correlation, and Analysis of Variance (ANOVA). Data analysis found that Roberts County mathematics teachers held beliefs consistent with a problem-solving (or student-centered) view of mathematics however they were undecided (did not agree or disagree) with the instrumentalists' view of mathematics.

Teachers favored a classroom environment that allowed students to communicate about mathematics and to express their concerns about their own learning. Teachers' beliefs about the nature of mathematics and their classroom learning environment were found to be statistically, positively significant with regard to the problem-solving view of mathematics (TBS sub-scale) and the CLES sub-scales. Elementary, middle, and high school teachers' beliefs differed. Elementary teachers were more likely to have problem-solving oriented beliefs and had classrooms which supported a constructivist learning environment. Elementary teachers supported mathematics by making connections to mathematics outside of school, encouraging students to communicate about mathematics, providing a safe learning environment that allowed students to express concerns about their learning and to share control of their learning. Recommendations to further Roberts County's mathematics teachers towards a more problem-solving and constructivist classroom learning environments are guided by the ideals of the *National Council of Teachers of Mathematics* publications and the *Georgia Performance Standards* for mathematics.

INDEX WORDS: Teacher beliefs, Social constructivism, Learning environment, National Council of Teachers of Mathematics, Georgia Performance Standards, Mathematics teachers, Elementary school teachers, Middle school teachers, High school teachers

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DEDICATION

I dedicate my dissertation to the endless support of my husband, Robby and my parents, Tom and Nancy Brechin. They have provided me with the support and time necessary accomplish my goal! I love my husband and parents dearly. I would also like to thank my mother-in-law, Emily Rich for helping our family through this long journey. My children, Cole and Chase, have constantly reminded me of what is truly important- that is spending time with them and having fun. My husband and children always made me smile or laugh when I just didn’t think I would ever finish!

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In writing this dissertation, I have often wondered if I would ever finish…

With the support of my committee chair, Dr. Gregory Chamblee, I have finally persevered. I would like to thank him for the time he has spent making sure that I was on the right path and for the time he spent editing my work.

I would also like to thank my committee members, Dr. Sharon Taylor and Dr. Dan Rea for being a part of my committee. They have hung in there with me and participated over past couple of years as I worked through this process. Also, special thanks to Dr. Stephen Jenkins for becoming a part of my committee and working as my methodologist over the past several months.

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CHAPTER 1

INTRODUCTION

Background of the Study

As a mathematics educator for 16 years, I have been deeply involved in mathematics curriculum and teaching in my county. I am currently a mathematics coach in Roberts County and prior to this, my experience was in the classroom. The role of a mathematics coach in my county includes providing model lessons in the classroom, planning collaboratively with teachers for effective mathematics instruction, working with teachers and administrators to support instruction and student achievement, and providing professional learning courses and in-services for mathematics teachers. This change in roles has provided me with the opportunity to work with not only students in the mathematics classroom but teachers as well. As a collaborator and observer, I have come to realize that the classroom environment and the teaching practice utilized by the teacher are key factors of student learning.

I have found in my county, teaching practices which involve active student involvement in learning mathematics is not a practice that is consistently prevalent in mathematics classrooms. Today however, many national, state, and county initiatives are requiring mathematics teachers transition their teaching practices to meet this expectation.

Current federal legislation, *No Child Left Behind* (NCLB), requires all students meet or exceed State standards in reading and mathematics on or before 2012 (U.S. Department of Education, 2002). To meet this achievement mandate, school systems and schools are placing an emphasis on teaching practices that may increase test scores (standardized test scores). Many mathematics education researchers and curriculum developers are positing the best way to reach this mandate is by "learning mathematics with understanding". This type of learning best occurs when children are in classrooms that place an emphasis on problem-solving, reasoning, and communicating their ideas and thinking to others" (Wood, 2001, p. 116).

A variety of documents and curricula movements over the past twenty-six years, such as *The Cockcroft Report* (1982), *A Nation at Risk* (1983), *Everybody Counts: A Report to the Nation on the Future of Mathematics Education* (1989), *National Council of Teachers of Mathematics Curriculum and Evaluation Standards for School Mathematics*

(CESSM)(1989), and the *National Research Foundation* curriculum projects (beginning in the 1990's), have supported efforts to enhance active student involvement in mathematics learning (Chung, 2003; Schoenfeld, 2005). These documents posit this type of change (reform) can only occur via changes in how mathematics is taught. In brief, this movement focuses on "revising the conventional views of mathematics learning as the mastery of a fixed set of facts and procedures" to a "process of investigation, sense-making, and communication in classroom activities" (Lloyd, 2002, p. 149). In general, this type of 'teaching and learning' change has been labeled the 'reform' movement in mathematics education and according to Van de Walle (2004), although the "reform movement is in its second decade, its goals have not yet been realized by a large majority of school districts" (p. 9).

Since the publications of the *National Council of Teachers of Mathematics* (NCTM) CESSM document, NCTM has continued to emphasize the importance of students "learning mathematics with understanding" in publications such as *Professional Standards for Teaching Mathematics* (PSTM) in 1991, and *Principles and Standards for School Mathematics* (PSSM) in 2000. These documents, according to Lambdin and Walcott (2007) "reflect the influences of a constructivist theory of learning” (p. 17). The relationship between students learning mathematics with understanding and constructivism according to Newmann, Marks, and Gamoran (1996), requires students to go beyond the “routine retrieval or reproduction of knowledge” (p. 286).

Changing the teaching and learning of mathematics via a constructivistic paradigm, began in Georgia after the results of a *Phi Delta Kappa* (PDK) curriculum audit in 2001 was published. The *PDK* curriculum audit found that Georgia’s standards in mathematics “were not well-aligned to versions of model national standards and that the focus in the classroom reflected knowledge acquisition and no evidence of analyzing, synthesizing, or evaluating” (Jacobson, 2002, p. 20). As a result of the PDK audit and NCLB requirements, Georgia revised its mathematics curriculum to more closely model national content recommendations. The aim of Georgia’s newly revised mathematics curriculum is to “actively engage students in the development of mathematical understanding” (Georgia Department of Education, 2005, p. 1).

The focus of mathematics education is “not only which mathematical concepts are important for students to master, but also-perhaps most important-how students learn” (Lambdin & Walcott, 2007, p. 17). Therefore, placing students at the center of instruction as opposed to "learning specific skills" through direct teacher instruction should be the emphasis of mathematics education (Wood, 2001, p. 111). The emphasis on reform in mathematics is on restructuring teaching methods, mathematics curricula, and student understanding of mathematical concepts as opposed to the memorization of algorithmic, process oriented strategies in mathematics (Manouchehri & Goodman, 1998).

In response to the requirements of NCLB and Georgia's newly adopted GPS curriculum, one of Roberts County's mathematics goals now is to increase all student achievement in the area of mathematics. In order to impact student achievement in mathematics, professional learning must focus on the reform-based teaching practices promoted by NCTM and by the GPS mathematics curriculum. The challenge of meeting this goal is how to structure professional development to help teachers modify methods of teaching which align to reform-based teaching practices (Nathan & Knuth, 2003; Baxter, Woodward, Voorhies & Wong, 2002; Ball, 1996).

Important to teacher beliefs research was the connection between beliefs about what teachers do in the classroom, beliefs about students' mathematics learning, and mathematics reform based on GPS and NCTM expectations. Constructivist learning theories support the “development of students’ personal mathematical ideas” through “interactions with mathematical tasks”, other students, and the teacher (Clements & Battista, 2002, p. 7). The underlying theoretical framework of this study is based upon Ernest’s social constructivist philosophy of learning mathematics.

In research involving mathematics teaching reform, a question that researchers often ask is, “Why are some teachers reluctant to change and hold fast to their traditional methods while others are embracing reform practices and changing the environment of their mathematics classroom?” (Hart, 2002, p. 162). There is strong evidence that teacher beliefs influence mathematics teaching practices (Wilson & Cooney, 2002; Thompson, 1992, 1984). Teacher beliefs research spanning from the early 1970’s to the 1980’s focused on teachers’ behaviors in the classroom (Thompson, 1992). From this outcomes based research evolved research that included “identifying and understanding the composition and structure of teachers’ beliefs” and how these beliefs impacted mathematics teaching and learning (Thompson, p. 129, 1992).

These beliefs, whether conscious or unconscious, act as “driving forces in shaping the teacher’s behavior” in the classroom (Thompson, 1984, p. 105). “Teachers’ beliefs about the nature of mathematics influence their beliefs about what it means to learn and do mathematics” (Mewborn & Cross, 2007, p. 260). Consequently, teacher instructional practices and student learning are impacted (Mewborn & Cross, 2007). Teacher’s belief about the classroom learning environment connects the social environment of the classroom to the practices of teachers and the interactions between students and teachers (Thornton & Wilson, 1993). Rooted in social psychology, learning environment research since the 1960’s and 1970’s provided a way to examine the role of the teacher in the classroom, teachers’ practices in the classroom, and the role of the student in the classroom. To determine the relationship between teachers’ beliefs about mathematics and their classroom learning environment, teachers’ beliefs were categorized according to Ernest (1991). Ernest’s (1991) categorization includes the role of the teacher, the role of the learner, and the goal of mathematics.

According to Ernest (1991), teachers’ beliefs about the nature of mathematics range from an instrumentalist view, which includes the discipline of mathematics as being static, the learner’s role is to master skills, and the goal of learning is skill mastery with correct answers, to a problem-solving view which includes the learner’s active construction and exploration, resulting in effective problem-solving. In addition to teacher’s beliefs about the nature of mathematics is the way in which the teacher views the role of the teacher and student in the classroom learning environment. As advocated by NCTM (2007), the classroom learning environment should include support and encouragement for student’s mathematical thinking, provide opportunities for communication to justify and develop mathematical understandings, and “provide a climate for students to take intellectual risks in raising questions and formulating conjectures” (p. 40).

My role in Roberts County school system is that of mathematics teacher support and a mathematics professional developer. I am interested in how to help mathematics teachers understand the role of the GPS and NCTM standards in teaching mathematics and how to implement effective teaching practices advocated by the GPS and NCTM standards. To help teachers understand and implement effective teaching practices aligned with national, state, and county expectations, it is important that research about teachers’ beliefs about the nature of mathematics and their classroom learning environment provide adequate information to help guide professional development needs. Therefore, the purpose of my study was to determine the relationship between teachers’ beliefs regarding the nature of mathematics and their classroom learning environment.

Purpose of the Study

The purpose of this study was to determine the relationship between teachers’ beliefs regarding the nature of mathematics and their classroom learning environment in Roberts County. Manouchehri and Enderson (1999) believe that the teacher plays a crucial role in the process of mathematics teaching and learning because “the teacher sets the climate of the class, creates an environment safe enough for students to explore and negotiate, and helps students build and share knowledge” (p. 222).

Handal (2003) found that teachers’ beliefs are “cogent enough to either facilitate or slow down” the implementation of effective teaching practices because of the complicated interplay between internal and external factors (p.47). The complicated relationship found between mathematics teachers’ beliefs and their classroom learning environment from prior studies provides a rationale for studying Roberts County’s mathematics teachers’ beliefs as teachers are mandated to implement practices consistent with GPS and NCTM expectations. Lloyd (2002) suggests that "the success of current mathematics education initiatives depends on our identification of viable ways to encourage and enable teachers to make significant shifts in their beliefs" (p. 150). Understanding teachers' beliefs about the nature of mathematics and their classroom learning environment will positively impact both teachers and students by providing effective professional development. Lloyd (2002) stresses that "a major challenge for professional development is to help teachers make sense of constructivist learning theories" to change their classroom learning environment and teaching practices (p. 150).

Research Questions

The following research questions were the focus of this study:

1. What beliefs do mathematics teachers in Roberts County hold regarding:
    a. The nature of mathematics?
    b. Their classroom learning environment?
2. Are there relationships between mathematics teachers' beliefs regarding the nature of mathematics and their classroom learning environment in Roberts County?
3. Are there differences between elementary, middle school, and high school mathematics teachers' beliefs

regarding the nature of mathematics and their classroom learning environments in Roberts County?

Significance of the Study

Researching teacher beliefs and the relationship between beliefs regarding the nature of mathematics and their classroom learning environment is important to further the understanding of how to effectively support a change in teachers' practices. Research about mathematics teacher beliefs is significant to mathematics education for three reasons. These are: (1) enhancing current knowledge regarding teacher beliefs about the nature of mathematics, (2) enhancing current knowledge regarding teacher beliefs about the classroom learning environment (3) helping professional developers find strategies to help teachers implement teaching practices advocated by the *National Council of Teachers of Mathematics* and the *Georgia Performance Standards* for mathematics.

Research in the area of teacher beliefs is important in teacher development and teacher education (Wilson & Cooney, 2002). Research studies involving mathematics teachers of a variety of grade levels find that there is a significant relationship between beliefs and practice (Wilson & Cooney, 2002; Thompson, 1992). Thompson (1992) emphasizes the importance of helping teachers "examine their own beliefs and practices" and helping teachers "consider alternatives" to their current teaching practices (p. 143). This study contributed to beliefs research by providing insight into the beliefs of mathematics teachers K-12 within a single school system.

Second, this study about Roberts County mathematics teachers K-12 allowed the researcher the opportunity to examine the relationships between teachers' classroom learning environments and their beliefs about the nature of mathematics. The NCTM publications, *Curriculum and Evaluation Standards for School Mathematics* (1989), *Professional Standards for Teaching Mathematics* (1991), and *Principles and Standards for School Mathematics* (2000) provide a clear vision of "what a high-quality mathematics education is comprised of". The expectations set by these NCTM documents in comparison with Roberts County teachers' practices provided additional guidance for effective professional development. This comparison also determined whether or not teachers possessed this vision as Georgia moves towards a more conceptually-based curriculum.

Third, as Georgia's mathematics curriculum promotes active student involvement in teaching students mathematics for understanding, teacher practices must change to reflect the expectations of a new curriculum. Chapman (2002), Ball

(1996), and Thompson (1984) suggest that the role of teacher beliefs to instructional practices needs to be studied further and a greater understanding of teachers' beliefs needs to be explored to help teachers with reform efforts. Understanding the beliefs of Roberts County's mathematics teachers provided the data necessary to determine teacher's needs during the transition between math curricula. As a professional developer for Roberts County, it was important to collect data that will help professional developers provide locally relevant professional development. Relevant professional development would allow teachers to look at their beliefs about the nature of mathematics and their classroom learning environment more critically.

Limitations

There were three limitations in this study. First, participants were from one school system. The results of this study may not be generalizable to other school systems due to differences in teacher demographics. Second, all teachers were expected to answer survey questions honestly. Finally, the researcher is a professional developer in the county being studied. Participants' answers may be impacted by this fact.

Definition of Terms

The following terms are defined because of their application to this study.

Classroom Learning Environment-The psychosocial environment which includes the teaching practices utilized by the teacher and the interactions between teachers and students in the classroom learning environment (Walker, 2004)

Cognitive Constructivism- Based on the work of Piaget, it is a theory of cognitive development whereby humans must construct their own knowledge through experiences; however, the construction of knowledge is based upon the development of one's cognitive abilities (assimilation and accommodation) (von Glasersfeld, 2007).

Constructivism- "A philosophy on how knowledge is created or obtained" (Warrick, 2001, p. 6)

Georgia Performance Standards (GPS)- a set of mathematics standards that provide a mathematics curriculum framework that promotes "the active engagement of students" in their development of mathematics understanding (Georgia Department of Education, 2005).

Nature of Mathematics- The way in which mathematics is perceived as a discipline; whether one sees mathematics as a static discipline that is an unchanging collection of rules, facts, and formulas, or whether one sees mathematics as a dynamic discipline that is ever-changing as a result of experimentation and discovery (Dossey, 1992).

Reform-based mathematics- Reform-based mathematics involves an epistemological shift from concepts and procedures to an emphasis on solving non-routine problems, an emphasis on the role of the teacher as facilitator, and an environment which reflects the social culture of the classroom for the purpose of making mathematics accessible to everyone. (Hiebert, Carpenter, Fennema, Fuson, Wearne, Murray, Olivier, & Human, 1997; Romberg, 1992).

Roberts County- a pseudonym which represents the participating county in this research study

Social Constructivism- A theory that knowledge is "actively constructed in the human mind" however, the development of that formal knowledge is determined by societal influences (Richardson, 2003, p. 1625).

Summary

This study focused on determining the relationship between mathematics teachers' beliefs regarding the nature of mathematics and their classroom learning environment. As a mathematics coach and professional developer, there was a need to better understand teachers' classroom practices to implement national, state, and local mathematics expectations. In order to teach students mathematics for understanding, expectations at the national, state, and local levels expect teacher instructional practices to change. This change includes teaching methods that focus on student understanding of mathematical concepts and a lessened focus on the memorization of algorithmic, process oriented strategies. This change also includes classroom learning environments that support risk-taking, communication, and justification of mathematical ideas. These expectations are a result of documents published by NCTM, which promotes teaching practices that are conducive to students' understanding of mathematics, and to Georgia's newly adopted mathematics curriculum, the *Georgia Performance Standards* for mathematics.

An important factor influential in the way teachers teach mathematics is teachers' beliefs about the nature of mathematics and their classroom learning environment. Research about mathematics teachers' beliefs show that beliefs are "considered as the cornerstone of their teaching practice" (Charalambous, Philippou, & Kyriakides, 2002, p. 217). As a researcher, gaining insight into

Roberts County’s teachers’ beliefs was an important part of understanding how to support mathematics teachers as they are expected to meet national, state, and county expectations. Research about teachers’ beliefs emphasizes “that a greater and more explicit focus needs to be on teachers’ beliefs” as opposed to specific pedagogy and tools (Beswick, 2006, p. 17).

Therefore, to provide insight into how to best meet mathematics teachers’ professional development needs in Roberts County, this research study determined the relationship between teachers’ beliefs regarding the nature of mathematics and their classroom learning environment and to help the professional development needs of Roberts County mathematics teachers.

CHAPTER 2

LITERATURE REVIEW

Introduction

This study investigated the relationship between teachers' beliefs regarding the nature of mathematics and their classroom learning environment. The purpose of this chapter is to establish a theoretical framework to examine mathematics teachers' beliefs regarding the nature of mathematics and their classroom learning environment and the relationship between the two. Literature that is important to this study includes: the theoretical perspectives of constructivism, social constructivism, teacher beliefs, classroom learning environment research, and the relationship between teachers' beliefs regarding the nature of mathematics and their classroom learning environment.

The relationship between teachers' beliefs about the nature of mathematics and their classroom learning environment was examined through the lens of constructivism. Constructivism is "a philosophy on how knowledge is created or obtained" (Warrick, 2001, p. 6).

Mathematics education researchers, for the past two decades, have primarily studied teacher professional development, student learning, and concept development through constructivistic lenses. For example, Cobb, Wood, and Yackel (1990) and Maher and Alston (1990) studied mathematics learning and teaching in the early 1990's using constructivism as their underlying research framework. The next section discusses the constructivistic underpinnings of my study.

Theoretical Framework

The roots of constructivism can be traced back to the philosophies of ancient Greece and to Giambattista Vico who in the 1700's published theories about the construction of knowledge (von Glasersfeld, 1990, p. 19; Warrick, 2001). Within the last century and a half, Piaget and Vygotsky made important contributions to the study of how knowledge is constructed. It is from their work that more recent philosophies of constructivism have evolved.

Initially, Jean Piaget's early theory of knowledge or cognition provided the basis for constructivism. In *The Construction of Reality in the Child* (1954), Piaget explains in great detail the complex stages by which a child interacts with his environment and constructs meaning. Piaget identified four stages of development: (1)

Sensorimotor stage, (2) Preoperational stage, (3) Concrete Operational stage, and (4) Formal Operational stage. Through these stages, children's experiences are providing a background or schema that enables them to assimilate new concepts (Piaget, 1978). For Piaget, development and construction of knowledge is personal to individuals as they make sense of their worlds. Piaget, through his development of theories about how knowledge is constructed, is best identified for his contributions to cognitive constructivism (Noddings, 1990).

Vygotsky critiqued and contrasted much of Piaget's work. Vygotsky (1986), in *Thought and Language*, states "to summarize the central flaws in Piaget's theory, we would have to point out that it is reality and the relations between a child and reality that are missed in his theory (pp. 51-52). According to Vygotsky (1978), "skills and knowledge which are experienced in a social setting" become internalized (p.130). Vygotsky's expansion of cognitive constructivism, as studied by Piaget, to include the social influences of the construction of meaning is today known as social constructivism. Vygotsky's (1978) social constructivist theory posits that "all the higher functions originate as actual relations between human individuals" (p. 57). Vygotsky (1978) notes three knowledge construction functions are affected by interaction: the formation of concepts, the development of voluntary attention, and logical memory. Vygotsky's expansion of constructivism into the social influences of the construction of meaning is relative to the nature of interaction which takes place in the classroom between teachers and students. Vygotsky's social constructivism theory provides a means for interpreting the interactions between teachers, students, and the classroom environment.

More specifically, social constructivism encompasses the interactions of the learner and his environment. Vygotsky (1978) writes, "Social relations or relations among people genetically underlie all higher [cognitive] functions and their relationships" (p. 57). The importance of social interaction in mathematics learning can be found in research studies which range from subjects like children's mathematical thinking to pre-service teacher education (Jaworski 1998, 1994; Ernest 1994, 1990; Cobb, Wood, & Yackel 1990; Confrey, 1990).

Piaget's underlying theory of knowledge construction and Vygotsky's social constructivism is the basis for radical constructivism advocated by Ernst von Glasersfeld. For von Glasersfeld (1990), the two basic principles of radical constructivism are that knowledge is built upon by the learner as an active participant in the learning process and the second principle is that the construction of meaning is adaptive in making the best sense possible of the learner's experiential world. Von Glasersfeld (2001) believes that knowledge is a result of an individual's constructive activity.

In summary, the basic tenets of constructivism as a theory of knowing or learning has two basic principles: "(1) Knowledge is actively constructed by the learner, not passively received from the environment and (2) *Coming to know* is a process of adaptation based on and constantly modified by a learner's experience of the world" (Jaworski, 1993, p. 1). The influences of the early theories of constructivism and construction of knowledge can be found in educational research, educational reform, and teaching practices. The perspectives of cognitive, social, and radical constructivism each encompass the basic tenets of the social constructivist theory.

Social Constructivist Theory

Ernest (1994) proposes a social constructivist theory of learning mathematics. Ernest acknowledges the influences of Piaget's cognitive constructivism (1954), von Glasersfeld's radical constructivism (1990), and Vygotsky's social constructivism (1986).

Ernest’s (1990, 1994) social constructivist theory of learning mathematics encompasses two principles of radical constructivism (principles a & b) and Vygotsky’s social constructivism perspective (principles c-f). The relationship between Ernest’s (1990, 1994) and von Glasersfeld’s radical constructivism are outlined in Table 1.

Table 1

Relationship Between Constructivist Philosophies: Ernest, von Glasersfeld, and Vygotsky

Ernest's (1990) Social Constructivistic Theory Tenets	Relationship to von Glasersfeld (2007) and Vygotsky (1978)
a. knowledge is not passively received but actively built up by the cognizing subject;	von Glasersfeld (2007)
b. the function of cognition is adaptive and serves the organization of the experiential world, not the discovery of ontological reality;	von Glasersfeld (2007)
c. the personal theories which result from the organization of the experiential world must 'fit' the constraints imposed by physical and social reality;	von Glasersfeld (2007)
d. they achieve this by a cycle of theory-prediction-test-failure-accommodation-new theory;	Vygotsky (1978)
e. this gives rise to socially agreed theories of the world and social patterns and rules of language use;	Vygotsky (1978)
f. mathematics is the theory of form and structure that arises within language	Vygotsky (1986)

Note. References from "Social constructivism as a philosophy of mathematics: Radical constructivism rehabilitated?", P. Ernest, 1990.

The principles of Ernest's social constructivistic philosophy of learning mathematics provide the underlying theoretical framework for this study.

Social Constructivist Theory and Mathematics

Beyond the learner's construction of knowledge, are the "wider interactions between the learner (student) and their social and cultural environment of the classroom" (Jaworski, 1994, p. 28). Constructivism as a theory of learning has been studied over a number of decades. However constructivism as a theory of practice or teaching "has only received attention for approximately one decade" (Richardson, 2003, p. 1623).

Richardson (2003) found that a "significant shift from considerations of how individual students learn to ways of facilitating that learning, first in individual students and then in groups of students" in the classroom influenced subject matter associations like the *National Council of Teachers of Mathematics* (NCTM) (p. 1626). This influence resulted in "a number of programs of learning standards based on constructivist principles" as well as "materials that suggested approaches to teaching" (Richardson, 2003, p. 1626; Matthews, 2000).

The *Curriculum and Evaluation Standards for School Mathematics* (CESSM) (1989) was the first nationally developed standards document. CESSM promoted significant changes in the teaching and learning of mathematics (reform mathematics) (NCTM, 1989). Among the fifty-four content standards presented in the CESSM (1989) emphases were placed on teaching mathematics. The CESSM (1989) standards were "based on societal goals, student goals, research on teaching and learning, and professional experiences" (pp. 7-9). Specifically, CESSM Evaluation Standard 13, Instruction, focuses on how mathematics should be taught.

The 1991 NCTM publication, *Professional Standards for Teaching Mathematics* (PSTM), "provided guidance to those involved in changing mathematics teaching" (NCTM, 1991, p. 2). *PSTM* (1991) posited "five major shifts in the environment of the mathematics classroom" that are needed in order for "teaching for the empowerment of students," to occur (NCTM, 1991, p. 2). These five shifts are:

1) Classrooms as mathematical communities-- away from classrooms as a collection of individuals;

2) Logic and mathematical evidence as verification-- away from the teacher as the sole authority for right answers;
3) Mathematical reasoning-- away from memorizing procedures;
4) Conjecturing, inventing, and problem solving-- away from an emphasis on mechanistic answer finding
5) Connecting mathematics, its ideas, and its applications-- away from treating mathematics as body of isolated concepts and procedures (NCTM, 1991, p. 2).

Overall, PSTM provides mathematics educators with clear expectations of the role of the classroom environment in teaching and learning mathematics.

In 2000, NCTM published, *The Principles and Standards for School Mathematics* (PSSM). The focus of this document was to update CESSM and discuss 21st century teaching and learning mathematics, classroom learning environment, and mathematics curriculum expectations. PSSM posits there are six guiding principles to the successful mathematics classroom: Equity, Learning, Curriculum, Assessment, Teaching, and Technology. The Teaching Principle emphasizes understanding “what students know and need to learn and then challenging and supporting them to learn it well”

(NCTM, 2000). The six standards of the Teaching Principle address: (1) worthwhile mathematical tasks, (2) the teacher’s role in discourse, (3) the student’s role in discourse, (4) tools for enhancing discourse, (5) the learning environment, and (6) the analysis of teaching and learning” (NCTM, 2000, p. 17). From the six standards of the Teaching Principle, the learning environment is described in the following excerpt:

> Teachers establish and nurture an environment conducive to learning mathematics through the decisions they make, the conversations they orchestrate, and the physical setting they create. Teachers' actions are what encourage students to think, question, solve problems, and discuss their ideas, strategies, and solutions. The teacher is responsible for creating an intellectual environment where serious mathematical thinking is the norm. More than just a physical setting with desks, bulletin boards, and posters, the classroom environment communicates subtle messages about what is valued in learning and doing mathematics (NCTM, 2000, p. 18).

In addition, the PSSM (2000) re-emphasized the importance of students learning mathematics with understanding. The PSSM (2000) Learning Principle complements the Teaching

Principle by supporting the need for students to have an understanding of mathematics that includes conceptual understanding, factual knowledge, and procedural proficiency. The Learning Principle states that “students must learn mathematics with understanding, actively building new knowledge from experience and prior knowledge” (NCTM, 2000, p. 20). The prior statement is similar to Ernest’s (1990) social constructivist theory in that a part of social constructivism is that “knowledge is actively built by the cognizing subject” (p. 17). Additionally, the Learning Principle states that “the kinds of experiences teachers provide clearly play a major role in determining the extent and quality of students’ learning” (NCTM, 2000, p. 21). These experiences include allowing for “classroom interactions, proposing mathematical ideas and conjectures, and reflecting upon their own and others mathematical thinking” (NCTM, 2000, p. 21). Social constructivism, according the Ernest (1990), involves learning which is “adaptive” and “serves the organization of the experiential world” and involves learning that “must ‘fit’ the constraints imposed by social reality” (p. 17).

Overall, the NCTM *Standards* publications, CESSM (1989), PSTM (1991), and PSSM (2000) provide guidance to teachers about how to teach mathematics and provide a basis for decisions which effect mathematics teaching and learning (PSSM, 2000). The NCTM *Standards* publications include aspects that are in agreement with a social constructivist theory.

Georgia Performance Standards

Georgia has recently undergone a curriculum change. This change brings with it new expectations for Georgia’s teachers in terms of their instructional practices and classroom learning environments. The introductory paragraph of the mathematics Georgia Performance Standards (GPS) summarizes the focus of Georgia’s Mathematics Curriculum. The focus of GPS is: 1) to actively engage students in mathematics understanding, 2) to have students “work independently and cooperatively to solve problems”, 3) to provide opportunities for students to “think critically and understand that there are many different ways to a solution and sometimes more than one right answer”, and 4) to provide opportunities for students to make connections between mathematics and other contexts (Georgia Department of Education, 2005, p. 1). The focus for the GPS relates to aspects found in Ernest’s social constructivist theory of mathematics. The aspects of Ernest’s (1990) social constructivist theory and the GPS which are similar are that of active involvement in learning and for students to think critically to formulate solutions on the basis of their physical and social world.

The *Georgia Performance Standards* (GPS) in mathematics now more closely align with documents like NCTM’s (2000) *Principles and Standards for School Mathematics* (PSSM). PSSM (2000) provides Process Standards to “highlight ways of acquiring and using content knowledge” (p. 29). The PSSM Process Standards are Problem-Solving, Reasoning and Proof, Communication, Connections, and Representation. The GPS for mathematics presents five Process Standards which characterize for teachers the extent to which students in mathematics need to utilize the content. Georgia’s Process Standards read exactly as the PSSM Process Standards. Table 2 provides a list of the GPS Process Standards and the corresponding PSSM Process Standards.

Table 2.

Relationship Between the GPS and PSSM Process Standards

GPS Process Standards:	PSSM Standards:
MP1. Students will solve problems (using appropriate technology). a. Build new mathematical knowledge through problem solving. b. Solve problems that arise in mathematics and in other contexts. c. Apply and adapt a variety of appropriate strategies to solve problems. d. Monitor and reflect on the process of mathematical problem solving.	Problem-Solving Standard (NCTM, p. 52, 2000)
MP2. Students will reason and evaluate mathematical arguments. a. Recognize reasoning and proof as fundamental aspects of mathematics. b. Make and investigate mathematical conjectures. c. Develop and evaluate mathematical arguments and proofs. d. Select and use various types of reasoning and methods of proof.	Reasoning & Proof Standard (NCTM, p. 56, 2000)
MP3. Students will communicate mathematically. a. Organize and consolidate their mathematical thinking through communication. b. Communicate their mathematical thinking coherently and clearly to peers, teachers, and others. c. Analyze and evaluate the mathematical thinking and strategies of others. d. Use the language of mathematics to express mathematical ideas precisely.	Communication Standard (NCTM, p. 60, 2000)

Table 2 (continued)

Relationship Between the GPS and PSSM Process Standards

MP4. Students will make connections among mathematical ideas and to other disciplines. a. Recognize and use connections among mathematical ideas. b. Understand how mathematical ideas interconnect and build on one another to produce a coherent whole. c. Recognize and apply mathematics in contexts outside of mathematics.	Connections Standard (NCTM, p. 64, 2000)
MP5. Students will represent mathematics in multiple ways. a. Create and use representations to organize, record, and communicate mathematical ideas. b. Select, apply, and translate among mathematical representations to solve problems. c. Use representations to model and interpret physical, social, and mathematical phenomena.	Representation Standard (NCTM, p. 67, 2000)

Note. The summary provided in the table is described in the *Georgia Performance Standards for Mathematics*, 2004, p. 4 and in the NCTM, *Professional Standards for School Mathematics*, 2000, p. 52-71.

The GPS mathematics Process Standards emphasize student understanding via providing opportunities for students to analyze and synthesize mathematics concepts. The GPS Process Standards parallel the PSSM standards of

Problem-Solving, Reasoning and Proof, Communication, Connections, and Representation (NCTM, 2000).

To implement the GPS Process Standards the classroom learning environment must encompass aspects related to the PSSM Teaching Principle that are important for student learning to take place. These are: "(1) an atmosphere of respect and value for students' ideas and ways of thinking, (2) a climate for taking intellectual risks in raising questions and formulating conjectures, and (3) encouragement for the student to display a sense of mathematical competence by validating and supporting ideas with a mathematical argument" (NCTM, 2007, p. 40). Thus, the role of the teacher is to create a classroom learning environment which allows students these opportunities.

There are many direct relationships between social constructivism, the PSSM Standards, and GPS for mathematics. To implement the NCTM standards and the GPS for mathematics, it is important to take into consideration teachers' beliefs regarding the nature of mathematics and their classroom learning environment.

Teacher Beliefs and Social Constructivistic Theory

Although "constructivism, as a theory of learning, says nothing directly about teaching" there are "a range of pedagogical practices" that are consistent with its principles (Beswick, 2007, p. 98). Teaching mathematics should involve practices that promote “the ways in which knowledge is constructed and exchanged in the classrooms” and involves the norms that teachers and students share in the culture of the classroom (Ball, 1991, p. 44). To understand teachers’ decisions and actions in the classroom, one must know the “beliefs or principles motivating teachers” as they implement their decisions and actions (Beswick, 2005, p. 98; Watson & De Geest, 2005; Thompson, 1992, 1984; Nickson, 1992).

Mathematics education research in the early to mid 1970’s, primarily focused on analyzing teaching using a “behavioristic (outcomes-based) framework” (Wilson & Cooney, 2002, p. 127). In the late 1970’s and continuing into the 1980’s, the research paradigm began to shift from the narrow perspectives of outcome based studies to investigations about teacher cognition, behaviors, attitudes, and decisions (Wilson & Cooney, 2002; Thompson, 1992). According to Wilson and Cooney (2002), research during the 1980’s focused on the “context in which teaching occurred” (p. 128). This “context” included not only the “physical arrangement of the classroom, but also of teachers’ beliefs about mathematics and its teaching” (Wilson & Cooney, 2002, p. 128). Thompson’s “extensive review of research on teachers' beliefs" and her realization of the impact of beliefs on mathematics reform, numerous studies have documented beliefs of mathematics teachers (Wilson & Cooney, 2002, p. 128). Recently, 'beliefs-based' research studies have focused on "(a) how students learn, (b) what mathematics is, (c) the characteristics of the students, and (d) teaching itself" (Koehler & Prior, 1993, p. 282).

An important factor in the history of beliefs research has been how to define teacher beliefs with regard to research. "The words *belief* or *believe* have many meanings in common usage" (Wilson & Cooney, 2002, p. 129). Barkatsas & Malone (2005) contend that an important factor in the research of teacher beliefs is "the non-alignment of terminology used by mathematics education researchers" (p. 70). Mathematics education researchers have adopted definitions for the word beliefs based on the perspectives of researchers Rokeach (1968) and Green (1971). Additionally, studies have used Ernest's model of beliefs system to define beliefs (Barkatsas & Malone, 2005; Beswick, 2004; Charalambous, Philippou, & Kyriakides, 2002).

For this study, the word beliefs will be examined according to Ernest's model of beliefs system. Ernest

(1991) bases teacher beliefs on three components: 1) the teacher's view or conception of the nature of mathematics, 2) the teacher's model or view of the nature of mathematics teaching, and 3) the teacher's model or view of the process of learning mathematics" (¶ 3). "The teacher's conception of the nature of mathematics is his or her belief system concerning the nature of mathematics as a whole" (Ernest, 1989, p. 250). According to Ernest (1989), this conception of the nature of mathematics may not be consciously held views, but account for the teacher's overall philosophy of mathematics discussed in the following section.

The Nature of Mathematics

Ernest (1991) acknowledges that the overarching influence directly affecting mathematics and its teaching is "the teacher's philosophy of the nature of mathematics" (p. 58). This overall philosophy determines "what they (teacher) consider to be valuable" or the goal of mathematics education (Ernest, 1989, p. 250). Ernest's (1989) categorizations of teacher's philosophies or belief systems are dependent upon how a teacher views the nature of mathematics or views the discipline of mathematics. These philosophies are "the instrumentalist view (mathematics is an accumulation of facts, rules, and skills), the Platonist view (mathematics is static but unified body of certain knowledge), and the problem-solving view (mathematics is dynamic and involves a process of inquiry and coming to know)" (p. 99). The hierarchy ranges from instrumentalist or teacher-directed to problem-solving or student-centered views of the nature of mathematics (Ernest, 1991). A summary of Ernest's (1989) categorization of teacher belief systems, based upon how a teacher views the nature of mathematics, is given in Table 3 below.

Table 3.

Ernest's Categorization of Teacher Beliefs

Views of the nature of mathematics	Goal or outcome	Teacher's Role	Learner's Role
1. Instrumentalist (teacher-directed)	Skills mastery with correct performance	instructor	Compliant behavior and mastery of skills model
2. Platonist	Conceptual understanding with unified knowledge	explainer	reception of knowledge
3. Problem-solving (student-centered)	Confident problem-posing & problem solving	facilitator	active construction, exploration & autonomous pursuit of own interests

Note. The summary provided in the table is described in "Mathematics Teacher Education and Policy" by P. Ernest, *Assessment & Evaluation in Higher Education*, 1991, p. 56-65.

Ernest's philosophy provides a way to "focus attention on a number of crucial aspects of belief and practice in mathematics teaching" (Ernest, 1991, p. 59). Research regarding the nature of mathematics beliefs of elementary, middle, and high school teachers are discussed in the following section.

Research Regarding Nature of Mathematics Beliefs

For the purposes of this study, research studies related to the role of elementary, middle, and high school mathematics teachers' beliefs regarding the nature of mathematics, which include a change in teaching methods as a result of reform efforts, mathematics curricula and materials, and/or an understanding of children's mathematics learning, are presented.

Elementary School Research

A teacher's beliefs about the nature of mathematics encompass what the teacher considers the goal of mathematics, their role in teaching mathematics, and the role of the learner (Ernest, 1989). The purpose or outcome of research involving elementary school teachers range from understanding the relationship between beliefs and practice to utilizing beliefs to guide methods to change practice that support student-centered classrooms as emphasized in reform-based mathematics (Warfield, Wood, & Lehman, 2005; Mewborn, 2002; Anderson, 1998; Cobb, Boufi, McClain, & Whitenack, 1997).

The *Mathematics Teacher Development Project* (MTD), a study conducted by Simon, Tzur, Heinz, Kinzel and Smith (2000) focused on teacher practices through "whole-group teaching experiments in teacher education courses and case studies of individual participants" (p. 581). By "teacher practices", the researcher meant "what teachers do, what they think about what they do, and their motivations for the actions they take" (Simon, et al., 2000, p. 581). Researchers analyzed participants (n=19) by video tape and observation to determine the perspectives of teachers' instructional practices. The goal of the *MTD* project was to understand how "teachers' practices develop from ones based on traditional conceptions of mathematics, learning, and teaching toward practices that are based on conceptions that are more consistent with principles underlying current mathematics education reform efforts" (Simon, et al., 2000, p. 581). Simon et al. found that teachers tend to "assess whether the children *see* the mathematical relationships rather than how the children *think* about the mathematics" (Simon, et al., 2000, p. 599).

Anderson (1998) surveyed elementary mathematics teachers (n=174) from twenty-one elementary schools in New South Wales to determine "what teachers believe and how they view their own practice" (p. 2). Using survey data about teachers' views and practices, Anderson (1998) found the majority (75%) of teachers place importance on number facts and basic skills, despite the fact that teachers felt problem solving motivated students. Teacher responses strongly supported survey statements which aligned with "traditional (instrumentalist) views of mathematics" (Anderson, 1998, p. 7). Additionally, the learner's role in the classroom was best defined by survey statements that supported algorithmic procedures for skills practice, problem-solving that included procedural knowledge and teacher guidance, and a de-emphasis on calculator use (Anderson, 1998). Anderson (1998) concluded that there are clear differences between what is recommended by the curriculum documents for New South Wales and teachers' instructional practices.

Grant and Kline (2001) conducted a case study with a fifth grade mathematics teacher to "better understand the ways a teacher utilizes a reform elementary mathematics curriculum" (p. 691). Researchers utilized an ethnographic approach to "obtain a clearer picture of what a teacher brings to the implementation of a new curriculum, the teacher's beliefs about mathematics teaching, his understanding of student's reasoning, and the ways he engaged with his students' reasoning were analyzed" (Grant & Kline, 2001, p. 691). Grant and Kline (2001) concluded although the teacher agreed with the constructivist nature of the curriculum, the teacher was unable in practice to follow this philosophy (Grant & Kline, 2001). As a result of the case study, Grant and Kline (2001) were able to re-affirm a key finding from their larger study, involving 400 elementary teachers concerning the implementation of curricular materials. This key finding was that "one of the most important factors (of successful implementation of reform curriculum) is the teacher's ability to engage with students' ideas" (Grant & Kline, 2001, p. 696).

Research about the relationship between elementary teacher beliefs and teacher practice are consistent with current literature finding that teacher beliefs have a strong impact on teacher actions (Ball, Lubienski, & Mewborn, 2001; Koehler & Prior, 1993; Thompson, 1992). Researchers have continued to recognize the importance of the relationship between teacher beliefs (teacher's goal or purpose of teaching mathematics) and teacher instructional practices (the role of the teacher and the role of the learner) in the classroom learning environment.

Middle School Research

Thompson (1984) believes that teacher beliefs play a significant role in shaping the characteristic patterns of teacher instructional behavior. Thompson (1984) studied three junior high school mathematics teachers to understand whether "the teachers' professed beliefs, views, and preferences about mathematics and mathematics teaching were reflected in their instructional practices" (p. 107). By conducting case studies, Thompson (1984) concluded that there is a complex relationship between beliefs about teaching mathematics and teaching practice. Thompson's (1984) results yielded beliefs about mathematics which range from mathematics as a static discipline to a discipline of discovery and verification as well as teacher practices that were teacher-centered (teacher as locus of control) to student-centered (students doing and actively engaging in mathematics). Thompson's (1984) study supported her original belief which "regardless of whether they (beliefs) are consciously or unconsciously held, they play a significant role in shaping the teachers' characteristic patterns of instructional behavior" (p. 124).

Nathan and Knuth (2003) conducted a two-year case study with a sixth-grade mathematics teacher to determine the relationship "between a sixth-grade teacher's beliefs and goals and how these beliefs manifest in her instructional practices" (p. 201). The subject was a participant in an intervening professional development program. Research included "weekly classroom observations, written field note accounts, biweekly debriefing sessions with the teacher and audiotapes of summer meetings with the teacher" (Nathan & Knuth, 2003, p. 181). Nathan and Knuth

(2003) found that the teacher held her own beliefs about what “reform-based mathematics” should look like in the classroom (p. 179). Over a two-year period, Nathan and Knuth (2003) focused on the “changes in whole classroom interactions” (p. 181). Although Nathan and Knuth (2003) set out to show that instructional change is a result of one’s beliefs and practices, the participating teacher changed instructional practice, but did not change her beliefs (Nathan and Knuth, 2003).

In a study of sixty-six middle school teachers, Manouchehri and Goodman (1998) conducted research over a 2-year period involving 12 different school districts in Missouri. The purpose of the study was to review and evaluate four standards-based curricular materials (Manouchehri & Goodman, 1998). Manouchehri and Goodman (1998) used a combination of research techniques: “observations of teachers’ classroom instruction; field notes on regional meetings and state conferences; researchers’ logs and field notes; individual and group surveys; and unstructured interviews with participating teachers” (p. 29). Manouchehri and Goodman (1998) found that teachers’ who used student-centered, constructivist practices were excited about the curricular program. After 5 months only 20 of the 66 teachers were using the curricular program. The use and evaluation of a curricular program and classroom activities were largely a result of their beliefs about constructivist-based practices and teaching mathematics (Manouchehri & Goodman, 1998). Manouchehri and Goodman's (1998) conclusions about the use of curriculum-based materials were: 1) the use of material depended on "the amount and quality of teachers' experiences"; 2) their professional knowledge base about curriculum and instruction; 3) the contexts in which they worked; 4) and their own personal theories of effective teaching and learning practices (p. 38-39).

Clarke (1997) conducted a study about the role of teachers' beliefs regarding instructional practices and a change in curricular materials. His findings from a case study of two middle school teachers identified factors that were influential in teacher change (Clarke, 1997). Participants of the study were involved in ongoing professional development to support instructional approaches derived from a social constructivist perspective (Clarke, 1997, p. 282). Clarke (1997) found that the two teachers, after this support, had differing views of mathematics learning. An important outcome of Clarke's (1997) research was that ongoing support can have an effect on teacher’s beliefs about the nature of mathematics teaching and learning.

Through teacher support, as Williams (1996) found in a case study involving a middle school mathematics teacher, teacher change can occur in teacher beliefs and practice. Williams (1996) conducted a case study with one middle school mathematics teacher, who “participated in a middle school mathematics program offered by the local university and authors of the curriculum” (p. 28). After two years of participating in the program, the middle school teacher built upon and refined her beliefs about mathematics teaching and learning by using more student-student interaction and communication (student-centered practices) to develop reasoning and understanding about mathematics. The result of increased student understanding and knowledge helped the teacher realize that changing her role from teacher-directed to that of facilitator could effectively impact students (Williams, 1996).

The research presented about middle school teacher beliefs and teacher practices involves understanding the influence of beliefs on practice. Researchers are finding that support for teacher change are found in reform documents (literature which promotes a change in teaching methods), mathematics curricula and materials which promote problem solving, and ongoing support which includes teaching approaches and understanding children's mathematics learning. However, teacher's belief changes do not always occur given a curriculum change.

High School Research

Research related to high school mathematics teachers' beliefs was similar to middle school research in that studies focused on teachers' instructional approaches in relation to mathematics reform measures (Beswick, 2007; Barkatsas & Malone, 2005; Breyfogle & Van Zoest, 1999).

Beswick (2005) surveyed twenty-five secondary mathematics teachers from six secondary schools in Tasmania to assess their beliefs about the nature of mathematics. Participants completed Beswick's survey, the *Teacher Beliefs Survey*, to categorize beliefs based on two of Ernest's philosophies of beliefs about the nature of mathematics and mathematics learning (Beswick, 2004). The two categories of Ernest's model of teachers beliefs used in Beswick's (2004) survey were the problem-solving and instrumentalist views of mathematics. From the teachers (n=25) surveyed, Beswick (2005) determined that fifteen teachers held instrumentalist views of the nature of mathematics and ten teachers held problem-solving views of the nature of mathematics. Beswick's (2004) study utilized teacher’s beliefs data in conjunction with student survey’s to generate data about the relationship between teachers’ beliefs about the nature of mathematics and their classroom learning environment.

Barkatsas and Malone (2005) surveyed 600 secondary mathematics teachers in Greece to assess “teachers’ beliefs about mathematics, mathematics teaching, mathematics learning and their teaching practice” (p. 75). Four hundred sixty-five teachers returned the survey (78% return rate). Barkatsas and Malone (2005) found that teachers who hold a “contemporary-constructivist orientation” strongly favor a socio-constructivist view, a dynamic problem-solving view and a cooperative view of mathematics and teachers who hold a “traditional-transmission-information processing orientation” strongly favor a static view and mechanistic view of mathematics (Barkatsas & Malone, 2005, p. 80). Barkatsas and Malone’s (2005) analysis “revealed that mathematics teachers’ beliefs about mathematics could not be separated from their beliefs about teaching and learning mathematics” (p. 80). Findings from their study are in agreement with other researchers such as Ernest (1989), Cooney (1999), and Pajaras (1992) who contend that “it is not possible to separate mathematics teachers’ views about mathematics from their views about teaching and learning" (Barkatsas & Malone, 2005, p. 80).

Andrews and Hatch (1999) conducted survey research in three regions of England involving 200 secondary schools to "explore aspects of teachers' conceptions of mathematics and its teaching" (p. 208). The purpose of the study was to examine teachers' conceptions of mathematics in comparison to mathematics reform initiatives set out by the mathematics National Curriculum for England and Wales (Andrews & Hatch, 1999). From teachers' responses (n=577) five conceptions of mathematics and five of mathematics teaching were identified. The five conceptions of mathematics are that mathematics is: "(1) a personal economic tool, (2) a diverse and pleasurable activity, (3) an essential life tool, (4) a service provider, and (5) a curricular determination" (Andrews & Hatch, 1999, p. 213). The five conceptions of mathematics teaching were identified as: "(1) a process-oriented activity, (2) a skills oriented activity, (3) the teaching of the individual child, (4) a collaborative and cooperative act, and (5) involves the creation of a mathematically enriched classroom environment" (Andrews & Hatch, 1999, p. 213). Researchers examined data by using correlations between the conceptions of mathematics and the conceptions of mathematics teaching. Andrews and Hatch (1999) concluded that high school teachers conceptualize mathematics from an instrumentalist view of mathematics and tend to focus on mathematics processes and skills. These conceptions are contrary to England's national curricula documents.

Cavanagh (2006) conducted research involving 480 secondary schools in New South Wales. Questionnaires from respondents (n=193) determined the extent to which high school mathematics teachers were able to transition their teaching practices to meet the requirements of the reform document, *Years 7-10 Mathematics Syllabus* (Cavanagh, 2006). Thirty-nine teachers were selected and interviewed to elaborate about their beliefs about mathematics and the reform mathematics document. Cavanagh (2006) found that teachers' beliefs about the nature of mathematics did not support instructional approaches conducive to reform. For example, a majority of the teachers "regarded mathematical knowledge as immutable and so to the way it should be taught", meaning that teachers did not see a need to change their methods of instruction (Cavanagh, 2006, p. 119). Cavanagh's (2006) research found that teachers' need to be encouraged to reflect on their own learning experiences as well as those of their students, an understanding of student's cognitive processes needs to be studied by teachers, and ongoing professional development and support should be conducted to provide practical examples of tasks for teachers to implement and evaluate.

High school teacher beliefs research studies support that an understanding between teacher’s beliefs and instructional practices needs to be understood to impact any type of teacher change. Reform mathematics was a catalyst for research about the relationship between teachers’ beliefs and their instructional practices at the high school level.

In looking at elementary, middle, and high school teacher beliefs research, Wilson and Cooney (2002) recognize that there are “different emphases in research with different grade levels” (p. 133). Elementary school mathematics research involving teacher beliefs includes understanding the relationship between beliefs and practice as well as utilizing beliefs to guide methods to change practice to support a change in mathematics curricula or materials.

Research about middle school mathematics teacher beliefs regarding the nature of mathematics and their classroom learning environment involves understanding the influence of beliefs on practice and ways to support or transition teachers from teacher-directed practices and classroom learning environments to student-centered practices or classroom learning environments.

High school mathematics teacher beliefs research also has been conducted to further the understanding between teacher beliefs and teacher practices. Mathematics education research at the high school level has also included how teachers' beliefs impact the implementation of mathematics curricula and reform.

A common theme in teacher beliefs research in elementary, middle, and high school settings is the connection between teacher beliefs, teacher practices and the classroom learning environment. The next section discusses the role of classroom learning environment as it relates to teacher practices.

Classroom Learning Environment

In mathematics education, "the way in which instruction is planned and supported by the classroom environment is crucial to what students learn" (Thornton & Wilson, 1993, p. 269). For the purpose of this research study, learning environment was defined as the psychosocial environment which includes the teaching practices utilized by the teacher and the interactions between teachers and students in the learning environment (Walker, 2004).

"Learning environment research (in the 1920's) has its roots in the work of early social psychologists" according to Dorman (2002). Learning environment research was impacted greatly due to the work of Rudolf Moos and Herbert Walberg in the 1960's and Barry Fraser in the 1970's, which through their research, established a general framework for learning environment research (Walker, 2004; Dorman, 2002). Research about learning environments allows researchers to study the impact that social environments have on individuals and groups and allows teachers and researchers to become aware of the learning environment and how to make improvements to meet the needs of students (Walker, 2004).

Learning Environment Research

As the field of learning environment research has grown a variety of evaluative instruments have been developed to ascertain both student and teacher perceptions of the classroom. As listed in Walker's (2004) research, "instruments such as, the *Science Laboratory Environment Instrument* (SLEI) (Fraser, Giddings, & McRobbie, 1992), the *Constructivist Learning Environment Survey* (CLES) (Taylor, Fraser, & Fisher, 1997), the *What is Happening in this Classroom* (WIHIC) questionnaire (Aldridge, Fraser, & Huang, 1999), and the *Questionnaire on Teacher Interaction*

(QTI)(Wubbels, 1993)" are more recent and contemporary learning environment research instruments (p. 7).

The utilization of these instruments and others involve evaluating student perceptions or teacher perceptions of the classroom learning environment as well as making comparisons between student and teacher perceptions of the classroom learning environment.

Student perceptions of their learning environment are the primary focus of studies by Forgasz (1995), Goh and Fraser (1995), and Huang and Waxman (1996). Each of the studies utilized learning environment surveys to ascertain students' perceptions of their learning environments in mathematics.

Forgasz's (1995) study examined the "relationships among various affective variables, gender, and classroom environment dimensions associated with effective mathematics learning" with seventh grade mathematics students (n=732) from secondary schools in Melbourne, Australia (p. 219). Using the *Individual Classroom Environment Questionnaire* along with a survey to measure affective variables, Forgasz (1995) examined students' perceptions of their mathematics classroom learning environment. Forgasz (1995) concluded that there is a relationship between the affective variables and their perceptions of their classroom learning environment.

Goh and Fraser (1995) conducted a large scale survey in Singapore involving fourth and fifth grade students (n=1,512) to study the effect that the learning environment and the teacher-student relationships have on mathematics learning. Four different questionnaires were used to conduct the study: (1) *Questionnaire on Teacher Interaction*, (2) *My Class Inventory*, (3) *Liking Mathematics Scale*, and (4) *Mathematics Exercise* (Goh & Fraser, 1995). Goh and Fraser (1995) concluded that "better achievement and student attitudes were found in classes with a greater emphasis in teacher Understanding, Helping/Friendly and Leadership behaviors, and also in classes showing more cohesion and less friction" (p. 21).

Huang and Waxman (1996) studied the role of the learning environment in mathematics among specific populations of students in the southern United States. Huang and Waxman (1996) targeted Asian American students (n=360) identified as academically successful (n=180) with those who were not, to compare differences between the perceptions of learning environments of their mathematics classes. Huang and Waxman (1996) utilized three different surveys to examine the perceptions of the students. These surveys were: *Multidimensional Motivational Instrument*, *Classroom Environment Scale*, and *Instructional Learning Environment Questionnaire*. Through classroom learning environment surveys, Huang and Waxman (1996) concluded that the role of the affective domain was critical for students' success (Huang & Waxman, 1996). Classroom learning environment survey data revealed that students who "were more attentive and involved in activities and more attached to classmates" and who were more intrinsically motivated to succeed were successful in mathematics (Huang & Waxman, p. 12, 1996). These aspects of the learning environment impacted academic success.

Studies which have compared student and teacher perceptions of their learning environment include the studies of Rickards and Fisher (2000), Ben-Chaim, Fresko, and Carmeli (1990), and Blose and Fisher (2003). Rickards and Fisher (2000) studied the perceptions of high school teachers' (n=164) and students' (n=3,589) of their science learning environments and found differences between the perceptions of each. The purpose of the study conducted in Australia was to provide data about teachers' perceptions, students' perceptions, and the relationships that could be drawn between the two sets of results. Student and teacher data was collected using two versions of the *Questionnaire* *on Teacher Interaction*s. Researchers concluded that there were differences between student and teacher perceptions of the classroom learning environment and “that teachers (with regard to teacher-student interpersonal behavior) tend to perceive their classes more positively than their students” (Rickards & Fisher, 2000, p. 10). An important outcome of the research was that once the results were shared with teachers they were able to “reflect on their own teaching and verbal communication in the classroom” which in turn may result in a more desirable learning environment for students (Rickards & Fisher, 2000, p. 9).

In order to “determine to what extent teachers’ perceptions of the learning environment in mathematics classes coincided with those of their pupils”, Ben-Chaim, Fresko and Carmeli (1990) conducted research with junior high school mathematics teachers (n=60) and students (n=1,338) in Israel (p. 416). Comparisons between student and teacher perceptions of the mathematics learning environment were studied as well as the differences between the perceptions held by teachers of differing gender. The survey instrument used for the study consisted of eight subscales, two of which were added due to current trends in mathematics and the other six subscales were adapted from the *Learning Environment Inventory*. With respect to the survey sub-scales, five of the eight sub-scale results were different between the teachers and students (Ben-Chaim, Fresko, & Carmeli, 1990). Researchers found that “the largest most consistent differences were found regarding formality (discipline in the classroom) and competiveness (competition with one another)” (Ben-Chaim, Fresko, & Carmeli, 1990, p. 426).

At the elementary school level, Blose and Fisher (2003) conducted research with elementary mathematics teachers (n=2) and their students to collect data that would assess and describe their mathematics classroom environments in order to “establish an action research plan to improve student outcomes” (p. 1). Researchers used the *School Level Environment Questionnaire* to measure teachers’ perspectives and *My Class Inventory* to measure the students’ perceptions of their mathematics classrooms. The findings from the study provided the researchers and teachers with data to use towards making positive classroom environment changes. However, the willingness of the participants proved to be an obstacle (Blose & Fisher, 2003).

The studies of Blose and Fisher (2003), Rickards and Fisher (2000), Ben-Chaim, Fresko, and Carmeli (1990) were all with differing populations of teachers and students.

However a common conclusion can be drawn from each research study. The differing perceptions of students' and teachers' allow teachers to become more aware of the perceptions of their students and allow for teachers to transition or change aspects of their learning environment (Blose & Fisher, 2003; Rickards & Fisher, 2000; Ben-Chaim, Fresko, & Carmeli, 1990). Walker (2004) emphasizes that learning environment research can provide educators with valuable information that aides in improving their classroom learning environment.

This study utilized the *Constructivist Learning Environment Survey* (CLES) to understand the beliefs of Roberts County mathematics teachers' beliefs about their classroom learning environment. The purpose of the CLES was to provide the researcher data about teachers' perceptions of their own classroom learning environment.

Constructivist Learning Environment Survey

"The CLES enables researchers and teacher researchers to monitor the development of constructivist approaches" to teaching mathematics (Taylor, Fraser, & Fisher, 1997, p. 293). More specifically, the CLES is based upon a socio-constructivist or social constructivist view of knowledge. Therefore "knowledge results from human inquiry and must be validated against community norms" (Taylor, Fraser, &

Fisher, 1997, ¶ 9). The CLES is a Likert scale survey that measures the level of agreement with five subscales which reflect aspects of the classroom learning environment. The five scales measured by Taylor, Fraser, and Fisher (1997) are described in Table 4. "The higher the CLES score the greater conformity of the classroom (learning) environment with constructivist principles" (Beswick, 2005, p. 47).

Table 4.

The Five Scales of the Classroom Learning Environment Survey.

Personal Relevance	This scale focuses on the connectedness of school mathematics to students' out-of-school experiences and with making use of students' everyday experiences as a meaningful context for the development of mathematical knowledge.
Mathematical Uncertainty	This scale assesses the extent to which opportunities are provided for students to experience scientific/mathematical knowledge as evolving and as being culturally and socially determined.
Student Negotiation	This scale assesses the extent to which opportunities exist for students to explain and justify to other students their newly developing ideas, to listen attentively, reflect on the viability of other students' ideas, and reflect self-critically on the viability of their own ideas.
Critical Voice	This scale examines the extent to which a social climate has been established in which students feel that it is legitimate and beneficial to question the teacher's pedagogical plans, methods, and express concerns about any impediments to their learning.
Shared Control	This scale is concerned with the students being invited to share with the teacher control of the learning environment, including the articulation of learning goals, the design and management of learning activities, and the determination and application of assessment criteria.

Note. The summary provided in the table is described in "Monitoring the Development of Constructivist Learning

Environments" by P. Taylor, P. Fraser, & D. Fisher, Paper presented at the annual convention of the National Science Teachers Association, 1993, p. 6.

Constructivist Learning Environment Survey Studies

The CLES instrument has been used in research studies to measure the perceptions of students and teachers about the classroom learning environment.

Studies involving student perceptions of their learning environment have compared students' perceptions of their learning environment with other instruments, observations, interviews and/or other populations of students.

Roth and Bowen (1995) used the CLES along with informal and formal interviews of 8th grade science students (n=65) in Central Canada. Researchers were conducting the study to understand students' perceptions of science classes using an "open-inquiry" approach to learning (Roth & Bowen, 1995). Their findings from the CLES, along with the interviews and observations, revealed the extent which students were able to experience Shared Control, Critical Voice, Student Negotiation, and Personal Relevance. From interviews and observations, students' perceptions correlated with positive experiences and remarks from the open-inquiry approach utilized in their science class.

Aldridge, Fraser, Taylor, and Chen (2000) conducted their learning environment research with secondary science students from Australia (n=1,081) and from Taiwan (n=1,879). The purpose of the study was to "investigate the differences and similarities in students' perceptions of the constructivist approaches present in their science classes (Aldridge, Fraser, Taylor & Chen, 2000, p. 42). In addition to the *Constructivist Learning Environment Survey,* researchers determined through interviews and observations that students varied in degree to which Shared Control, Critical Voice, Student Negotiation, and Personal Relevance occurred in their classes. The CLES data showed that students "in Taiwan perceived the scales of Personal Relevance, Uncertainty, and Shared Control occurring more frequently and that students in Australia perceived the scales of Critical Voice and Student Negotiation as occurring more frequently" (Aldridge, Fraser, Taylor & Chen, 2000, p. 42). Variations between the data were found to be the result of cultural differences and the organization of the academic systems of the two countries (Aldridge, Fraser, Taylor & Chen, 2000).

Beswick's (2005) research focused on student perceptions of their learning environment by comparing student (39 classes) CLES results with teacher (n=25) beliefs about the nature of mathematics. The results of the study showed that students lacked the opportunity to select activities, set time frames, and justify solutions without teachers showing the method or solution to the problem (Beswick, 2005). Beswick used the students' CLES results to further research the relationship between students' perceptions of the classroom learning environment with teachers' beliefs about the nature of mathematics. Overall, findings show that the classroom learning environment appears to be impacted by the "ability level (as perceived by the teacher) and grade level of the class" and additionally curriculum pressures (Beswick, 2005, p. 64). In continuation of her initial work, Beswick (2004, 2005) utilized the CLES instrument along with the *Teacher Beliefs Survey,* the student CLES, and interview data. Beswick (2004) used the teacher version of the CLES instrument to measure teacher (n=1) perceptions of their classroom learning environment. Results from the teacher's data revealed that the students and teacher did not perceive the levels of student-centeredness to be the same. The teacher felt that more opportunities were provided for students to select tasks, and solve their own problems (without teacher solutions or methods) than did the students. Beswick (2004) concluded from this study that the teacher's beliefs, though consistent with mathematics education reform, were impacted by the ability level of the students he taught. Therefore, teacher beliefs must be considered in relation to specific contexts (Beswick, 2004).

Sebela (2004), in the initial phase of studying primary and secondary teachers (n=29) and students (n=1,843) regarding their perceptions of their classroom learning environment, utilized the CLES instruments in a large scale study in South Africa. The purpose of the study was to "seek information that will assist teachers to become reflective practitioners in their daily classroom mathematics teaching" (Sebela, 2004, p. 245). Curriculum change in South Africa, encompassing an "outcomes-based approach" which emphasizes learner centered approaches, prompted research to better "assist teachers in the development and implementation of their classroom practices" (Sebela, 2004, p. 246). Although research at the time the article was written was not complete, Sebela (2004) concluded that preliminary data showed overall "teachers all struggle to understand what constructivist (teaching) is all about" (p. 51).

Johnson and McClure (2004) conducted research involving elementary, middle, and high school beginning science and mathematics teachers (n=290) in Minnesota.

Along with interviews, videotaped lessons, and the CLES, researchers wanted to gather data about "teacher knowledge and beliefs, teaching performance, and the comparison of knowledge and beliefs to teaching performance" (Johnson & McClure, 2004). The researchers used the teacher CLES data, observations, interviews, and student CLES data to create profiles of participating teachers (Johnson & McClure, 2004, p. 72). The results of the study yielded a revision of the CLES instrument for subsequent studies as well as profiles of participating teachers which could be used to improve areas of their classroom learning environment (Johnson & McClure, 2004).

Summary

This study was concerned with the relationship between Roberts County teachers' beliefs regarding the nature of mathematics and their classroom learning environment. Discussed in this chapter were the historical perspectives and emergent themes of constructivism, teacher beliefs, research about beliefs of the nature of mathematics, and classroom learning environment perspectives and research.

The themes of constructivism are discussed to provide a historical overview of the theories of cognitive, social, and radical constructivism. Constructivism, as a theory of learning, can be defined broadly as: (1) the construction of knowledge by the learner is actively received, and (2) the process of learning is dependent on the learner's experiences. The theoretical framework to examine mathematics teachers' beliefs, their classroom environments, and the relationship between these constructs is based on Ernest's (1991) social constructivist theory of learning mathematics.

Perspectives about teachers' beliefs about mathematics are discussed to lay a foundation of research about teachers' beliefs. Historically, early research about teachers' beliefs focused on outcomes based studies. Since that time, research about teachers' beliefs have included the context of the classroom learning environment, as well as teachers' beliefs based on how students learn mathematics, what mathematics is, and how teachers teach mathematics which together encompass teachers' beliefs about the nature of mathematics. Research findings from elementary, middle school, and high school teachers' beliefs regarding the nature of mathematics have found that there is a need to study teachers' beliefs due to mathematics reform, a transition or change in curricular materials or curricula, and most importantly to impact student learning of mathematics.

Classroom learning environment research is important too. Classroom learning environment research focuses on the social environment which encompasses teaching practices and the interactions among teachers and students. Classroom learning environment research provides for educators a way to evaluate and improve upon the learning environment. Learning environment studies, which include a variety of research methods and instruments, have found that the classroom learning environment does impact student learning.

CHAPTER 3

METHODOLOGY

Introduction

An important part of teaching mathematics is what the teacher brings to the classroom learning environment. Jaworski (1989) notes that "a teacher's effectiveness in teaching a lesson is often determined by what actually occurred and what the teacher's own beliefs are about teaching and learning" (p. 170). Teacher belief studies about the nature of mathematics are an important part of teacher change (Beswick, 2006; Cooney, Shealy, & Arvold, 1998; Manouchehri & Goodman, 1998; Ernest, 1989). The purpose of this study was to examine relationships between Roberts County kindergarten through twelfth grade mathematics teachers' beliefs regarding the nature of mathematics and their classroom learning environment. Data was analyzed and compared using survey and demographic data collected from the mathematics teachers in Roberts County. This chapter describes the research design, instrumentation, procedures, and data analysis needed to examine Roberts County teachers' beliefs.

Research Questions

The research questions that were addressed by this study were:

1. What beliefs do mathematics teachers in Roberts County hold regarding:
   a. The nature of mathematics?
   b. Their classroom learning environment?
2. Are there relationships between mathematics teachers' beliefs regarding the nature of mathematics and their classroom learning environment in Roberts County?
3. Are there differences between elementary, middle school, and high school mathematics teachers' beliefs regarding the nature of mathematics and their classroom learning environments in Roberts County?

The Setting

This study was conducted during Spring Semester 2008 in Roberts County. Roberts County is a suburban school system located in middle Georgia. The school system employs 2,067 teachers and has a school enrollment of approximately 25,800 students. Roberts County consists of thirty-eight schools: twenty-three elementary schools, eight middle schools, four high schools, and three alternative schools (2 middle schools, 1 high school).

Roberts County’s 2000 population was approximately 126,163. The ethnic breakdown of Roberts County is 69.2% Caucasian, 26.9% African American, and approximately 4% Hispanic. The median income of Roberts County is approximately $47,000 with approximately 12% of the county’s population living in poverty (United States Census Bureau, 2000).

Roberts County’s teacher population is primarily female (83%). Teachers in the county holding either a bachelor’s (43%) or master’s degree (39%) in teaching account for 82% of the teachers. Teachers holding a specialist’s (17%), doctoral (<1%), and other degrees make up the remaining teachers. Ethnicities consist of White (79%), Black (19%), Hispanic (<1%), Asian (<1%), and Native American (<1%) teachers. Roberts County teachers range in years of experience in teaching. The county consists of teachers having less than 1 year experience (14%), with one to ten years (42%), eleven to twenty years (25%), twenty-one to thirty years (15%), and greater than thirty years teaching experience (4%). The demographics of Roberts County teachers based on *The Governor’s Office of Student*

Achievement (2007) for school year 2006-2007 are summarized in Table 5.

Table 5.

Demographic Summary of PK-12 Teachers (n=1800)

Personnel Sub-Categories	Number of Personnel
Gender	
Male	305
Female	1,495
Certificate Level	
4 yr. Bachelor's	766
5 yr. Master's	710
6 Yr. Specialist's	306
7 Yr. Doctoral	16
Other	2
Race/Ethnicity	
Black	346
White	1,426
Hispanic	21
Asian	6
Native American	1
Years Experience	
< 1	257
1-10	752
11-20	444
21-30	273
> 30	74

Note. The summary provided in the table is described on *The Governor's Office of Student Achievement,* 2006-2007 System Report Card retrieved from http://www.ga-oea.org/FindASchool.aspx?PageReq=106&StateId=ALL

Participants

Roberts County has thirty-eight schools in the district. Three building level elementary school principals did not consent to participate in the study. From the thirty-five Roberts County schools, participants eligible for this study were teachers who taught at least one mathematics segment or class period daily during the 2007-2008 school years. Seven hundred eighty-four teachers met this definition in Roberts County. More specifically, 589 elementary teachers, 115 middle school teachers, and 80 high school teachers who teach mathematics were potential participants for this study (N=784).

A stratified random sample was used to select 300 survey participants. Stratified random sampling provided a proportional sample of participants from the elementary, middle, and high schools. In a random sample, each participant has an equal chance of being selected. By stratifying the sample, each sub-population (elementary, middle, and high school teachers) was represented in the study (Creswell, 2003). According to the populations of teachers who teach mathematics in the elementary, middle, and high schools, the surveys were distributed such that 75% of the participants were elementary teachers, 15% of the participants were middle school teachers, and 10% of the participants were high school teachers. Table 6 provides a summary of participants by school type.

Table 6.

Selection of Participants by School Type.

Type of School	Total Number of Schools	Number of Schools for Survey	Number of Teachers That Teach Mathematics	Percent of Teachers at Each School Type	Minimum Number of Teachers to be Surveyed (N=300)
Elementary	23	20	589	75%	225
Middle	9	9	115	15%	45
High	6	6	80	10%	30

From each of the participating elementary, middle, and high schools, teachers that teach mathematics were randomly selected to participate in the study. Participants were selected by using a random number generator. Using the number of potential participants at each school, participants were alphabetized by last name, numbered using a coding system, and then selected according to the random number generator. This process ensured that teachers were selected from each school in the county. The distribution of surveys was based on the number of teachers (N=300) participating in the study at the elementary school (n=225), middle school (n=45), and high school (n=30) levels. Schools that were surveyed and the maximum number of teachers that were surveyed at each school are located in Appendix A.

Research Design

This study was a quantitative study to examine Roberts County teachers' beliefs regarding the nature of mathematics and their classroom learning environment. Quantitative research methodology utilizes numbers to analyze and interpret data through scaling the information, and aggregating and summarizing the data (Romberg, 1992, p. 53). Quantitative data provided a way to analyze the beliefs of a large population of mathematics teachers in Roberts County. Considering the size of the population and the collection of data through surveys, utilizing quantitative research methods was the best approach for this study (Creswell, 2003).

Three quantitative instruments were used to collect data about these variables: (1) teachers beliefs about the nature of mathematics, (2) teachers beliefs about their classroom learning environment, and (3) demographics data about each teacher. Teachers' beliefs about the nature of mathematics were determined using the *Teacher Beliefs*

Survey (TBS) (Beswick, 2005). Teachers' perceptions of their classroom learning environment were determined using the *Constructivist Learning Environment Survey* (CLES) (Beswick, 2005; Taylor, Fraser, & Fisher, 1997). A teacher demographics survey was administered to collect data about each teacher's gender, years of teaching experience, current grade level teaching, certification, and educational background.

Instrumentation

Three quantitative surveys were used in this study: *Teacher Beliefs Survey* (TBS), *Constructivist Learning Environment Survey* (CLES), and a demographics survey.

Teacher Beliefs Survey

The *Teacher Beliefs Survey* (see Appendix B) consists of 26 items. Participants expressed their level of agreement with each statement by selecting a choice from a five-point Likert Scale that ranges from Strongly Agree (5) to Strongly Disagree (1). The *Teacher Beliefs Survey* has a scoring range from 26 to 130 which is found by adding the value of each level of agreement for each statement.

The *Teacher Beliefs Survey* (TBS) items can be divided to determine two subscale scores: problem-solving and instrumentalist views of mathematics. The problem-solving and instrumentalist views of mathematics are two of the three categorizations used by Ernest (1990) to categorize teacher beliefs. Fourteen items measure the level of agreement with the problem-solving view of mathematics. The remaining twelve items measure the level of agreement with an instrumentalist view of mathematics. Survey items that map to each subscale are shown in Table 7.

Table 7.

Teacher Beliefs Survey Subscale Item Numbers

Ernest's Beliefs Philosophies	Survey item #
Problem-solving view	1, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 17, 20, 23
Instrumentalist view	2, 7, 14, 15, 16, 18, 19, 21, 22, 24, 25, 26

For the purpose of this study, the mean scores for the survey subscale totals were used to determine the teachers' orientation towards problem-solving and instrumentalist views of mathematics. The scoring range for the problem-solving view of mathematics ranges from 14 to 70 based upon the total number of statements corresponding with the problem-solving view. Therefore, a higher problem-solving subscale score will indicate that a teacher views mathematics as a dynamic subject involving inquiry and discovery. The problem-solving view of mathematics includes student-centered approaches to learning mathematics. The scoring range for the instrumentalist view of mathematics ranges from 12 to 60 based upon the total number of statements that measure the instrumentalist view. A higher instrumentalist subscale score will indicate that a teacher views mathematics as an accumulation of facts, rules, and skills and tends to utilize teacher-directed methods.

Reliability and Validity

Beswick's (2005) *Teacher Beliefs Survey* instrument is a combination of two instruments: *Beliefs About Teaching Mathematics,* a thirty-five item survey designed by Van Zoest, Jones, and Thornton (1994), and an 18-item beliefs analysis by Howard, Perry and Lindsey (1997). The *Beliefs about Teaching Mathematics* survey designed by Van Zoest, Jones, and Thornton (1994) was based on measuring "a socio-constructivist approach to mathematics instruction" and was initially used with pre-service elementary teachers to compare "beliefs about mathematics and mathematics instruction" (Barkatsas & Malone, 2005, p. 71). The beliefs analysis, originally developed by Howard, Perry, and Lindsey (1997), was used by Perry, Vistro-Yu, Howard, Wong, and Keong (2002) to determine "teacher beliefs about mathematics and its learning and teaching" (p. 3).

Initially, Beswick (2005) piloted a 40-item survey which "consisted of all 35 items from *The Beliefs About Teaching Mathematics* survey designed by Van Zoest, Jones, and Thornton (1994) and an additional five items relating to the nature of mathematics taken from Howard, Perry, and Lindsey's (1997) survey" (p. 45). Beswick (2005) found the *Teachers Belief Survey* measured two factors, essentially corresponding with the respective views of mathematics teaching and learning that were identified as theoretically consistent with instrumentalist and problem-solving views of mathematics, via a "factor analysis of the pilot study" (p. 45). "Fourteen of the items included in the initial survey were omitted on the basis of feedback from participants in the pilot study concerning an appropriate length for the survey and factor analysis of the pilot study results" (Beswick, 2005, p. 46).

Beswick (2005), using the pilot study survey results, determined the alpha reliability coefficient associated with an instrumentalist view of mathematics factor to be 0.77 and the alpha reliability coefficient associated with a problem-solving view of mathematics factor to be 0.78.

Constructivist Learning Environment Survey

The *Constructivist Learning Environment Survey* (see Appendix C) is a 25-item Likert scale survey which measures overall teachers' perception of their classroom learning environment (Taylor & Fraser, 1991; Taylor, Fraser & White, 1994). The CLES was based on the theory of constructivism "that is concerned with developing teaching approaches that facilitate students' conceptual development" (Taylor, Fraser, & Fisher, 1997, p. 294). Participants selected from a range of Almost Always (5) to Almost Never (1) to describe their level of agreement with each statement. Scores for the CLES range from 25 to 125 and are calculated by adding together the level of agreement (1-5) with each statement. Researchers are able to use the scores "to monitor the development of constructivist approaches to teaching" mathematics (Taylor, Fraser, & Fisher, 1997, p. 293). A high total score indicates the greater the teacher's perception of a classroom environment that is consistent with constructivism. A low total score indicates the teacher's perception of a classroom environment that is not consistent with constructivist learning environment.

The *Constructivist Learning Environment Survey* statements also can be divided into five subscale scores: Personal Relevance, Mathematical Uncertainty, Student

Negotiation, Critical Voice, and Shared Control. The focus of the instrument according to Taylor, Fraser, and Fisher (1997) was facilitating students' conceptual development. Factors which influenced the development of the instrument were: (1) to engage students' prior knowledge in the development of new conceptual understandings, (2) incorporate the "reflective process of interpersonal negotiation of meaning within the domain of the classroom community", and (3) to restructure the teachers' role as mediators and facilitators of students' mathematical interpretations and reconceptualizations, as opposed to mediators of static, unchanging knowledge (Taylor, Fraser, & Fisher, 1997, p. 295). These five scales assess teachers' beliefs about their classroom learning environment that are relative to constructivism as outlined in Table 8.

Table 8.

Five Sub-scales of the Constructivist Learning Environment Survey

CLES Sub-scales	Definition
Personal Relevance	The extent to which teachers connect mathematics to the students' out-of-school experiences
Mathematical Uncertainty	The extent to which opportunities are provided for the students to experience mathematics knowledge as evolving and socially and culturally determined
Student Negotiation	The extent to which opportunities exist for students to explain and justify their ideas, to listen attentively, and to reflect on other students ideas as well as their own
Critical Voice	The extent to which a social climate has been established in which students feel that it is legitimate and beneficial to question the teacher's pedagogical plans, and methods in relation to their learning
Shared Control	The extent to which the student is invited to share with the teacher control of the classroom learning environment

Note. As referenced from Sebela, 2004; Taylor, Dawson & Fraser, 1995; Taylor, Fraser, & Fisher, 1997.

Five items measure the level of agreement with each of the subscales. Survey items that map to each subscale are shown in Table 9.

Table 9.

CLES Subscales and Survey Statement Numbers

Five Scales of the CLES	Survey Statement Numbers
Personal Relevance	1, 2, 3, 4, 5
Mathematical Uncertainty	6, 7, 8, 9, 10
Critical Voice	11, 12, 13, 14, 15
Shared Control	16, 17, 18, 19, 20
Student Negotiation	21, 22, 23, 24, 25

A high Personal Relevance subscale score indicates the teacher’s use of students’ everyday experiences to aid in the development of mathematical knowledge. A high Mathematical Uncertainty subscale score indicates that teachers have provided opportunities for students to see mathematics as evolving and understand that mathematics is socially and culturally determined. Teachers that have high Student Negotiation, Critical Voice, and Shared Control sub-scale scores are indicative of providing a classroom learning environment that promotes communication and self-reflection, student questioning and involvement in their own learning, and allow ‘shared control’ of learning goals, activities, and assessment, respectively.

Reliability and Validity

Initially, the 1991 CLES instrument contained fifty-eight items which focused on a “psychosocial view of constructivist reform” (Taylor & Fraser, 1991, p. 6). Through field testing and instrument validation procedures the instrument was shortened to 28 items (Taylor & Fraser, 1991, p. 6).

Further revision of the 28 item CLES reflected the goal of the researchers to incorporate recent research of the effectiveness of “communicative relationships between teachers and students” (Taylor, Fraser, and Fisher, 1997, p. 295). The revision of the CLES, included the removal of negatively worded items and redeveloped subscales to incorporate perspectives of a “socio-constructivist framework” meant to empower teachers toward reform (Taylor, Fraser, & White, 1994; Taylor, Dawson, & Fraser, 1995, p. 1). The CLES instrument, initially intended for student use, was validated for studies with students by Taylor, Fraser, and White (1994).

For this study, teachers were surveyed using the teacher version of the CLES. Validation of the teacher version of the CLES was completed in a study by Johnson and McClure (2004). The reliability of the overall instrument yielded a 0.88 alpha reliability coefficient which researchers agreed would be adequate in measuring teacher's agreement with each of the five sub-scales (Johnson & McClure, 2004).

Demographics Survey

The demographics survey (Appendix D) asks questions regarding teacher's gender, grade level currently teaching, total years of teaching experience, and educational degrees obtained. Data collected was used to disaggregate survey findings for the purpose of answering the research questions and determined the demographics of the teachers that completed the survey.

Procedures

The researcher obtained permission to conduct the study from the Institutional Review Board (IRB) (Appendix E) at Georgia Southern University, the Roberts County elementary, middle, and high school principals (Appendix F and the Roberts County Assistant Superintendent (Appendix G). Once the administration of surveys was approved, the researcher contacted the principals of the selected elementary, middle, and high schools in Roberts County that consented to participating in the study and arranged the administration (Appendix H) of the *Teachers Beliefs Survey*, the *Constructivist Learning Environment Survey*, and the demographics survey. The researcher delivered surveys to each participating school and distributed the survey packets, which included the three surveys, an informed consent letter, and a self-addressed envelope, to each teacher's mailbox. To collect the surveys and ensure that the participants' survey responses were kept confidential, participant names were not used; instead a coding system was used to represent the school type, school, and participant. Participants used the self-addressed, stamped envelope to return the completed surveys to the researcher's home. After the initial surveys were delivered and the researcher waited three weeks, follow-up letters and surveys were re-delivered to selected participants that had not responded (Appendix I). Repeating the procedure was an effort to gather a sufficient sample of teachers.

The researcher then entered data in SPSS 12.0. TBS data was then analyzed to determine whether teachers have a problem-solving or instrumentalists view of mathematics, as categorized by Ernest (1989). The data collected from the TBS was analyzed by calculating the total mean score of the

TBS subscale statements corresponding to the problem-solving (1, 3, 4, 5, 6, 8, 9-13, 17, 20, and 23) and instrumentalists (2, 7, 14-16, 18, 19, 21, 22, and 24-26) views of mathematics, for the county and by each school level, elementary (K-5), middle school (6-8), and high school (9-12).

The CLES, which determines a teacher's perceptions of their own classroom learning environment, provided data which indicated teachers' beliefs about their classroom learning environment using sub-scale statements for Personal Relevance (1-5), Mathematical Uncertainty (6-10), Critical Voice (11-15), Shared Control (16-20) and Student Negotiation (21-25). The data collected from the CLES were analyzed by calculating the mean score for the county and each school type, as well as other sub-populations.

Data Analysis

The data collected from the three surveys during Spring Semester 2008 from Roberts County kindergarten through twelfth grade teachers who teach at least one mathematics class were used to answer the three research questions.

For question one, the *Teacher Beliefs Survey* (TBS) and *Constructivist Learning Environment Survey* (CLES) subscale mean totals were calculated for all Roberts County teachers and by school level, elementary (K-5), middle (6-8), and high (9-12) school. Data was also analyzed using other demographic variables to determine differences in Roberts County teacher beliefs and classroom learning environments.

For question two, data was analyzed by correlating the sub-scales of the TBS and CLES which determined the relationship between the sub-scales of each survey. Correlational data was found for all K-12 mathematics teachers and for each school type to determine the relationship between the TBS and CLES.

For question three, Analyses of Variance (ANOVAs) was conducted to determine differences between teachers' beliefs regarding the nature of mathematics (TBS sub-scales) and their classroom learning environment (CLES sub-scales) by each school type: elementary, middle, and high school.

Summary

This study was conducted to examine the relationship between Roberts County kindergarten through twelfth grade mathematics teachers' beliefs regarding the nature of mathematics and their classroom learning environment. To determine this relationship, research was conducted Spring Semester 2008 with Roberts County K-12 mathematics teachers who taught at least one segment of mathematics a day. Elementary, middle, and high schools (N=35) which participated in this study were selected upon approval from their school’s principal as well as at the county level.

The *Teacher Beliefs Survey*, the *Constructivist Learning Environment Survey*, and a demographics survey were delivered to teachers at each of the participating schools. The surveys for elementary (n=255), middle (n=45), and high (n=30) school teachers were distributed based upon the county’s overall teacher population to obtain a representative sample. Teachers from each participating school were selected using stratified random sampling.

The TBS and CLES were used to determine mathematics teachers’ beliefs regarding the nature of mathematics their classroom learning environments. The survey results were analyzed using SPSS 12.0.

To answer survey question one, TBS and CLES sub-scales determined the teachers’ beliefs regarding the nature of mathematics and their classroom learning environment. Data was analyzed for all participating K-12 teachers and by school type.

For research question two, the TBS and CLES sub-scales were correlated to determine the relationship between mathematics teachers’ beliefs about the nature of mathematics and their classroom learning environment.

Analysis comparisons were made for all K-12 teachers and for each school type.

Research question three determined the differences between teachers at each school type (elementary, middle, and high school) regarding their beliefs about the nature of mathematics and their classroom learning environment by analyzing TBS and CLES sub-scale data.

Overall, survey data was used to determine the relationship between Roberts County kindergarten through twelfth grade teachers' beliefs regarding the nature of mathematics and their classroom learning environments.

CHAPTER 4

RESULTS

Introduction

This study was designed to examine relationships between Roberts County kindergarten through twelfth grade mathematics teachers' beliefs regarding the nature of mathematics and their classroom learning environment. Three quantitative instruments were used to determine the relationships: *Teacher Beliefs Survey* (TBS), the *Constructivist Learning Environment Survey* (CLES), and a demographics survey. This chapter will provide an overview of the K-12 Roberts County participants, as well as a detailed summary by grade level of participants. The chapter will also address the survey results as they pertain to the three research questions.

Participants

Survey participants for this study consisted of kindergarten through twelfth grade mathematics teachers in Roberts County that taught at least one segment of mathematics daily. Through stratified random sampling, 225 elementary teachers, 45 middle school teachers, and 30 high school teachers were sent three surveys to complete and return to the researcher (n=300). A total of 165 mathematics teachers completed and returned the three surveys for the study. The overall return rate for the surveys was 55%.

Participation among middle school mathematics teachers was the greatest with 75% of the teachers participating. The largest portion of surveys however was distributed to elementary school mathematics teachers due to the percentage of elementary teachers in Roberts County’s overall teacher population. Teachers at the elementary school level returned 49.78% of the surveys. High school teachers returned 63.33% of the surveys delivered to their schools. A summary of participation rates are given below in Table 10.

Table 10.

Participation Rates by School Type

School Type	Total Number Sent	Total Number Returned	Percent of Return
Elementary	225	112	49.78%
Middle	45	34	75.56%
High	30	19	63.33%
Total	300	165	55.00%

Of the participants, a majority of the teachers were female (n=140). The participants range in years of teaching experience from 1 to 38 years experience. The largest number in this category having between 1 and 10 years experience (n=86 or 52%). With respect to educational background, participants had earned Bachelors (n=52 or 32%), Masters (n=82 or 50%), and Specialist degrees (n=31 or 19%). Detailed participant demographics tables are found in Appendix J.

For each school type, elementary, middle, and high school participants' demographic variables varied the greatest for gender. Elementary school participants were a majority female (n=107) with 96% of the teachers being female. Middle and high school teacher percentages reflected higher male teacher participants than in elementary schools with 38% and 37% respectively. Participant's demographic data shows that elementary teachers (n=112) hold Bachelor's (29%), Masters (51%), and Specialists (20%) degrees. Middle school teachers' (n=34) demographic data shows that a majority of the teachers hold either a Bachelors (41%) or Masters (41%) degree, with a small number of teachers having a Specialists (18%) degree. High school teachers (n=19) hold Bachelors (32%), Masters (58%), and Specialists (10%) degrees. Demographic data for years of teaching experience showed that elementary participants (n=112) had fifty-one teachers (46%) between 1 and 10 years experience and forty-six teachers (41%) with 11 to 20 years experience. Only fifteen elementary teachers (13%) have 21 or greater years experience. Middle school teachers' (n=34) demographic data showed that 71% of the teachers have between 1 and 10 years (n=24) teaching experience, 24% between 11 and 20 years (n=8) teaching experience, and 5% with more than 20 years (n=2) of teaching experience. High school teachers' (n=19) demographic data showed that teachers having between 1 and 10 years (n=11 or 58%) experience and 26 to 38 years (n=6 or 32%) experience account for the majority of high school participants. Only two high school participants (10%) have between 11 and 25 years teaching experience according to the demographics data.

For this study, surveys were distributed to each school type based upon Roberts County's overall mathematics teacher population (elementary 75%, middle 15%, and high school, 10%). Survey participation at each school level closely reflected Roberts County's teacher population. A summary of percentages of the total number of participants at each school level are given below in Table 11.

Table 11.

Percent by School Type of Survey Participants

School Type	Total Number of Participants that Returned Surveys	Percent of Total Number of Participants (N=165)
Elementary	112	68%
Middle	34	21%
High	19	11%

In Roberts County, 20 elementary, 9 middle, and 6 high schools consented to participate in the research study. Of the participating schools, 100% of the schools at each level had participants return the three surveys. Also, of the participating elementary, middle, and high schools, every school had at least a 25% return rate among selected participants. A summary of schools with surveys returned is given below in Table 12.

Table 12.

Participating Schools with Surveys Returned.

School Type	Number of Schools Participating	Schools with Surveys Returned	Percent of School with Surveys Returned
Elementary	20	20	100%
Middle	9	9	100%
High	6	6	100%
Total	35	35	100%

The participants in the research study were representative of Roberts County mathematics teachers because sample sizes from each school type are similar to Roberts County's mathematics teacher population and every school participating in the study had at least 25% of the selected participants respond by sending in the three surveys for the study.

According the overall elementary, middle, and high school teacher participants' demographic data, participants were primarily female, with a Masters degree, and having between 1 and 10 years teaching experience. Participants for each school type vary slightly. Demographic data shows that participants for elementary school are primarily female, with a Masters degree, and have between 1 and 10 years teaching experience. Middle school teacher participants are primarily female with either a Bachelors or Masters Degree having between 1 and 10 years teaching experience. Participants at the high school level are primarily female, with a Masters degree, and have between 1 and 10 years teaching experience.

Analysis of the Data

Survey research conducted at the beginning of Spring Semester 2008 provided the data necessary to examine the relationship between Roberts County mathematics teachers' beliefs regarding the nature of mathematics and their classroom learning environment. This section presents the research questions used to guide the study along with an analysis of the data.

Research Question 1: What beliefs do mathematics teachers in Roberts County hold regarding:

a. The nature of mathematics?
b. Their classroom learning environment?

To answer this question, mathematics teachers K-12 completed two surveys: the *Teacher Beliefs Survey* (TBS) and the *Constructivist Learning Environment Survey* (CLES), (Appendices A and B). In determining teachers' beliefs about the nature of mathematics, the TBS sub-scales of problem-solving and instrumentalists views of mathematics were analyzed using mean totals for each sub-scale for all K-12 teachers and by school type. The CLES sub-scale mean totals were analyzed for all teachers K-12 and by school type and were used to determine teachers' beliefs about their classroom learning environment.

Beliefs about the Nature of Mathematics

Teachers' beliefs regarding the nature of mathematics was analyzed using the data collected from the TBS. To determine the degree to which teachers (K-12 and school type) were in agreement with the problem-solving or instrumentalist views of mathematics, as categorized by Ernest (1989), the mean of each sub-scale was calculated.

The scoring ranges for the problem-solving view of mathematics are 14 to 70, which is based upon the number of statements corresponding with the problem-solving view of mathematics (n=14) on the *Teacher Beliefs Survey*. The scoring ranges for the instrumentalist view of mathematics are 12 to 60, which is based upon the number of statements corresponding with the instrumentalist view of mathematics (n=12) on the *Teacher Beliefs Survey*. To determine the level of agreement with each sub-scale, the scoring range for the problem-solving and instrumentalist views were determined and scaled based upon the number of scale values (n=5). To determine the problem-solving range of scores, the value of each level of agreement: Strongly Agree (SA = 5), Agree (A=4), Not Decided (ND=3), Disagree (D=2), and Strongly Disagree (SD=1), was determined by multiplying the number of problem-solving statements (n=14) by each scale value. By doing this, the true value of each level of agreement could be determined for the fourteen statements of Problem-solving. Using the 14-point range between scale values and dividing by two, intervals for each level of agreement were determined. To determine the instrumentalist range of scores, calculating intervals for the scoring range was the same, however, calculations were based on twelve statements which represented the instrumentalist view of mathematics. Table 13 illustrates the scale used to represent the level of agreement with each sub-scale.

Table 13.

Scoring Range for TBS Sub-scales

Sub-scale	Level of Agreement	Scale Range
Problem-solving view of mathematics	Strongly Agree	70.0-63.0
	Agree	62.99-49.0
	Not Decided	48.99-35.0
	Disagree	34.99-21.0
	Strongly Disagree	20.99-14.0
Instrumentalist view of mathematics	Strongly Agree	60.0-54.0
	Agree	53.99-42.0
	Not Decided	41.99-30.0
	Disagree	29.99-18.0
	Strongly Disagree	17.99-12.0

The scoring range that represents each level of agreement allowed the researcher to categorize and interpret the mean values calculated for the county and for each school type with regard to mathematics teachers' beliefs about the nature of mathematics.

The mean total for the problem-solving view of mathematics of 60.37 falls within the range of *Agree*. Teachers that hold a problem-solving view of mathematics believe that mathematics is a dynamic subject involving inquiry and discovery, and believe in the use of student-centered approaches to learning mathematics. The mean total for the instrumentalist view of mathematics was 34.54, in the range of *Not Decided*. This mean indicated that teachers may have considered aspects of the instrumentalist or teacher-centered view as relevant to teaching mathematics. Table 14 shows the TBS sub-scale results for all participating Roberts County mathematics teachers.

Table 14.

Sub-scale Mean Totals for the TBS (K-12)

TBS Sub-scales	N	Min. Level of Agreement	Max. Level of Agreement	Mean	SD
Problem-solving view of mathematics	165	47	70	60.37	5.213
Instrumentalist view of mathematics	165	22	43	34.54	4.772

More specifically, kindergarten through twelfth grade teachers agreed with specific statements indicating their beliefs about the problem-solving nature of mathematics. Each level of agreement is represented by the following values: *Strongly Agree* (SA=5), *Agree* (A=4), *Not Decided* (ND=3), *Disagree* (D=2), and *Strongly Disagree* (SD=1). Table 15 lists statements that had the highest levels of agreement for the TBS problem-solving sub-scale.

Table 15.

Highest Levels of Agreement: TBS Problem-solving Sub-scale Statements.

Problem-solving Sub-scale Statements	Mean	SD
1. A vital task for the teacher is motivating children to solve their own mathematical problems.	4.67	.496
23. Teachers can create, for all children, a non-threatening environment for learning mathematics.	4.64	.553
5. It is important for children to be given opportunities to reflect on and evaluate their learning.	4.60	.527

The instrumentalist view of mathematics for mathematics teachers K-12 had a lower mean total than did the problem-solving view of mathematics. Of the twelve statements which represented the instrumentalist sub-scale, three statements had high levels of agreement among the three school types indicating that K-12 mathematics teachers also hold beliefs that are student-centered (problem-solving) as well as teacher-centered (instrumentalists). Table 16 lists statements that had the highest levels of agreement for the TBS instrumentalist sub-scale.

Table 16.

Highest Levels of Agreement: TBS Instrumenalist Sub-scale Statements.

Instrumentalist Sub-scale Statements	Mean	SD
7. It is important for teachers to understand the structured way in which mathematics concepts and skills relate to each other.	4.48	.640
21. There is an established amount of mathematical content that should be covered at each grade level.	4.13	.774
16. It is important that mathematics content be presented to children in the correct sequence.	3.99	.890

To determine if mathematics teachers differed in their beliefs about the nature of mathematics among school type, data was analyzed from elementary, middle, and high school teachers' responses to the TBS. Data indicated that the problem-solving view of mathematics for teachers at each school type was more favorable than that of the instrumentalist view of mathematics. The mean totals for the problem-solving view for each school type fell within the range of *Agree*. The teachers' level of agreement with an instrumentalist view was in the *Not Decided* range. Mean totals among the problem-solving and instrumentalists views were very close among each school type. Table 17 presents the results using the mean totals for the sub-scales of the problem-solving and instrumentalist views of mathematics.

Table 17.

Sub-scale Mean Totals for TBS by School Type

Problem-solving View of Mathematics

School Type	N	Min. Level of Agreement	Max. Level of Agreement	Mean	SD
Elementary (K-5)	112	47	70	59.96	5.390
Middle (6-8)	34	49	70	60.91	5.248
High (9-12)	19	54	70	61.84	3.746

Instrumentalist View of Mathematics

School Type	N	Min. Level of Agreement	Max. Level of Agreement	Mean	SD
Elementary (K-5)	112	22	43	34.66	4.969
Middle (6-8)	34	29	43	35.41	3.978
High (9-12)	19	24	41	32.26	4.382

Analysis of additional demographic variables (gender, years of teaching experience, and highest degree earned) did not yield any additional teachers’ beliefs about the nature of mathematics. A summary of the TBS demographic data analysis is in Appendix K.

Overall, Roberts County's teacher data indicated that there was a higher level of agreement with regard to the problem-solving view of mathematics. The instrumentalist view of mathematics for teachers K-12 indicated that teachers were less in favor of the sub-scale, however specific statements were found to be in agreement with the beliefs of teachers about the nature of mathematics.

Beliefs about Their Classroom Learning Environment

Data collected from the CLES was analyzed to determine teachers' beliefs regarding their classroom learning environment. The CLES determines a teacher's perceptions of their own classroom learning environment using the sub-scales of Personal Relevance (connecting mathematics to the students' out-of-school experiences), Mathematical Uncertainty (providing opportunities for students to see mathematics as evolving and understand that mathematics is socially and culturally determined.), Student Negotiation (providing opportunities for students to explain and justify their ideas, to listen attentively, and to reflect on other students ideas as well as their own), Critical Voice (establishing a social climate in which students feel that it is legitimate and beneficial to question the teacher's pedagogical plans, and methods in relation to their learning), and Shared Control (student sharing with the teacher control of the classroom learning environment).

The data collected from the CLES were analyzed by calculating the mean score of each sub-scale for the county and for each sub-population. The scoring ranges for each sub-scale are 5 to 25, based upon the number of statements (n=5) corresponding with each of the sub-scales on the CLES survey. To determine the level of agreement with each sub-scale, the scoring range for each sub-scale were determined and scaled based upon the number of scale values (n=5). For each sub-scale of the CLES, the value of each level of agreement: Strongly Agree (SA=5), Agree (A=4), Not Decided (ND=3), Disagree (D=2), and Strongly Disagree (SD=1), was determined by multiplying the number of sub-scale statements (n=5) by each scale value. By doing this, the true value of each level of agreement could be determined for the each of the five sub-scales of the CLES. Using the 5-point range between scale values and dividing by two, intervals for each level of agreement were determined. Table 18 illustrates the scale used to represent the level of agreement with each sub-scale.

Table 18.

Scoring Range for CLES Sub-scales

Level of Agreement	Scale Range
Strongly Agree	25.0-22.5
Agree	22.49-17.5
Not Decided	17.49-12.5
Disagree	12.49-7.5
Strongly Disagree	7.49-5.0

Overall, kindergarten through twelfth grade mathematics teachers were in agreement with statements of the sub-scales Critical Voice (M=21.43), Student Negotiation (M=21.07), and Personal Relevance (M=18.75). The mean totals of Shared Control (M=16.88) and Mathematical Uncertainty (M=12.58) indicated that teachers were *Not Decided* about these two sub-scales. The CLES sub-scale means of Personal Relevance, Mathematical Uncertainty, Critical Voice, Shared Control, and Student Negotiation for the county are presented in Table 19.

Table 19.

Sub-scale Mean Totals for the CLES (K-12)

CLES Sub-scales	N	Min. Level of Agreement	Max. Level of Agreement	Mean	SD
Personal Relevance	165	8	25	18.75	3.319
Mathematical Uncertainty	165	5	25	12.58	4.077
Critical Voice	165	8	25	21.43	3.445
Shared Control	165	5	25	16.88	4.302
Student Negotiation	165	10	25	21.07	3.430

Overall data shows that of the five sub-scales of the CLES, high school teachers' mean scores were the lowest for four of the five CLES sub-scales. The sub-scale values for each school type provided more detailed data about the teachers' level of agreement with the sub-scales of the CLES. Differences among sub-scale scores for Critical Voice were slight among the three school types. In contrast, the sub-scales of Personal Relevance, Mathematical Uncertainty, Shared Control, and Student Negotiation showed differences among the teachers from each type of school. The mean totals for Personal Relevance indicated that elementary (M=19.21) and middle (M=18.59) school teachers *Agree* with the statements supporting the sub-scale, whereas high school (M=16.37) teachers fell into the range of *Not Decided*. The sub-scale of Mathematical Uncertainty differed among middle (M=13.41) school teachers and high school (M=11.58) and elementary (M=12.49) school ranging from *Not Decided* to *Disagree*. Teachers' level of agreement for the sub-scale Shared Control indicated that elementary (M=17.28), middle (M=16.29) and high school (M=15.63) teachers were *Not Decided*. Mean totals for the sub-scale Student Negotiation ranged from 21.54 to 19.68 for elementary, middle, and high school teachers respectively and indicates that teachers *Agree* with the sub-scale. This may indicate that teachers believe their classroom learning environment promotes practices in which students are able to explain, justify, listen, and reflect on their ideas, as well as the ideas of others. The analysis of the sub-scale means for the CLES by school type is found below in Table 20.

Table 20.

Sub-scale Mean Totals for the CLES by School Type

School Type	N	Min. and Max. Level of Agreement	Mean	SD
Personal Relevance				
Elementary	112	8-25	19.21	3.335
Middle	34	13-25	18.59	2.935
High	19	13-22	16.37	2.948
Mathematical Uncertainty				
Elementary	112	5-25	12.49	4.228
Middle	34	7-20	13.41	3.483
High	19	5-18	11.58	4.073
Critical Voice				
Elementary	112	8-25	21.49	3.485
Middle	34	15-25	21.15	3.202
High	19	11-25	21.58	3.776
Shared Control				
Elementary	112	5-25	17.28	4.582
Middle	34	10-21	16.29	3.362
High	19	9-23	15.63	3.890
Student Negotiation				
Elementary	112	13-25	21.54	3.136
Middle	34	13-25	20.32	3.804
High	19	10-25	19.68	3.945

Analysis of additional demographic variables (gender, years of teaching experience, and highest degree earned) did show difference in teachers' beliefs about their classroom learning environment. For the sub-population gender, the mean totals which varied greatest were found in the sub-scales Critical Voice and Student Negotiation. In both cases, the female sub-population had a greater mean total. Differences were also found for the sub-populations, highest degree earned. For each sub-scale of the CLES, those teachers' with a Specialists degree had a higher mean total than those with Bachelors or Masters Degrees. A summary of the additional CLES demographic data analysis is in Appendix L.

Research Question 2: Are there relationships between mathematics teachers' beliefs regarding the nature of mathematics and their classroom environment in Roberts County?

To determine the relationship between mathematics teachers' beliefs regarding the nature of mathematics and their classroom learning environment, data was analyzed by determining the correlation between the CLES sub-scales (Personal Relevance, Mathematical Uncertainty, Student Control, Critical Voice, and Student Negotiation) and the

TBS sub-scales (problem-solving and instrumentalist views of mathematics). A Pearson correlation using SPSS 12.0 calculated the correlation.

Data analysis revealed that for each sub-scale of the CLES and the TBS sub-scale of problem-solving, there was a positive correlation. A correlation between problem-solving (TBS) and CLES sub-scales ranged from $r=.238$ to $r=.428$. This relationship indicates that a statistically significant correlation exists between the beliefs of mathematics teachers regarding the nature of mathematics and their classroom learning environment with regards to a problem-solving view of mathematics. The analysis revealed that there is a negative, non-significant correlation between an instrumentalist view of mathematics (TBS) and the sub-scales of the CLES. The results of the analysis are summarized in Table 21 below.

Table 21.

Pearson Correlation of CLES Sub-scales and TBS Sub-scales, K-12

CLES Sub-scales	TBS Sub-scales: Problem-solving		TBS Sub-scales: Instrumentalist	
	r	Sig.	r	Sig.
Personal Relevance	.238	.002*	.052	.507
Mathematical Uncertainty	.262	.001*	-.032	.683
Critical Voice	.338	.000*	-.085	.280
Shared Control	.261	.001*	-.011	.886
Student Negotiation	.468	.000*	-.024	.763

* $p<0.05$

Data analysis revealed that there are some differences among school types in the correlation between the CLES sub-scales and the TBS sub-scales. For elementary school teachers, the correlation indicated that there is a significant, positive correlation between each of the CLES sub-scales and the TBS sub-scale, problem-solving view of mathematics. The strongest correlation was between the problem-solving view of mathematics and Student Negotiation (r=.485).

The middle school data differed from the overall data, showing that only three of the CLES sub-scales, Critical Voice, Shared Control, and Student Negotiation, correlated with the problem-solving sub-scale of the TBS. Among the three correlations, both Shared Control ($r=.524$) and Student Negotiation ($r=.566$) were more strongly correlated than the overall K-12 teacher correlations. Data also revealed a significant, negative correlation between an instrumentalist view of mathematics (TBS) and Mathematical Uncertainty (CLES) ($r=-.465$).

From the Pearson correlation by school type, high school results showed that there exists no significant, positive or negative correlation between the CLES sub-scales and the TBS sub-scales, the problem-solving and instrumentalist view of mathematics. The results of the Pearson correlation are summarized in Table 22 below.

Table 22.

Pearson Correlation of CLES Sub-scales and TBS Sub-scales, by School Type

School Type	CLES Sub-scales	TBS Sub-scales: Problem-solving r	Problem-solving Sig.(p)	Instrumentalist r	Instrumentalist Sig.(p)
Elementary (K-5)	Personal Relevance	.308	.001*	.042	.662
	Mathematical Uncertainty	.306	.001*	-.030	.751
	Critical Voice	.361	.000*	-.141	.138
	Shared Control	.273	.004*	.035	.711
	Student Negotiation	.485	.000*	-.026	.782
Middle (6-8)	Personal Relevance	.238	.176	-.071	.691
	Mathematical Uncertainty	.223	.206	-.465	.006*
	Critical Voice	.345	.045*	-.067	.708
	Shared Control	.524	.001*	-.281	.107
	Student Negotiation	.566	.000*	-.173	.327
High (9-12)	Personal Relevance	.151	.536	-.081	.742
	Mathematical Uncertainty	.054	.827	-.084	.733
	Critical Voice	.219	.368	.286	.236
	Shared Control	-.119	.629	-.147	.548
	Student Negotiation	.177	.469	.079	.748

* $p<0.05$

Research Question 3: Are there differences between elementary, middle, and high school mathematics teachers' beliefs regarding the nature of mathematics and their classroom learning environments?

In order to determine the differences between elementary, middle, and high school teachers' beliefs regarding the nature of mathematics and their classroom learning environment, an Analysis of Variance (ANOVA) was used to analyze the data. In addition to the ANOVA analysis, the Tukey HSD (Honestly Significant Difference) Post Hoc test was used to determine more precisely which groups differed from one another if the ANOVA results indicated that there was a significant difference. For each of the sub-scales of the TBS (problem-solving and instrumentalist views of mathematics) and the CLES (Personal Relevance, Mathematical Uncertainty, Critical Voice, Shared Control, and Student Negotiation), the means from each school type (elementary, middle, and high school) were compared. This comparison determined whether or not differences between elementary, middle, and high school teachers' beliefs regarding the nature of mathematics and their classroom learning environment could be found.

The analysis of the data indicated that there are no significant differences in the beliefs of mathematics teachers with regard to the problem-solving view of mathematics. Table 23 summarizes the ANOVA results of the TBS problem-solving view of mathematics by school type.

Table 23.

ANOVA Results for TBS Problem-solving by School Type

K-12 Teachers	Sum of Squares	df	Mean Square	F	Sig. (p)
Between Groups	70.410	2	35.205	1.3	.275
Within Groups	4386.038	162	27.074		
Total	4456.448	164			

To completely analyze the sub-scales of the TBS for each school type, an ANOVA was also conducted for the TBS sub-scale, instrumentalist view of mathematics. Analysis of data using the ANOVA test indicated that elementary, middle, and high school teachers' beliefs of the instrumentalist view of mathematics does not differ significantly. The ANOVA results are shown below in Table 24 for each school type.

Table 24.

ANOVA Results for TBS Instrumentalist by School Type

K-12 Teachers	Sum of Squares	df	Mean Square	F	Sig. (p)
Between Groups	125.967	2	62.984	2.827	.062
Within Groups	3609.027	162	22.278		
Total	3734.994	164			

* $p<0.05$

From Tables 23 and 24, it was concluded that no significant differences existed between the beliefs of elementary, middle, and high school mathematics teachers' regarding the nature of mathematics. TBS sub-scale differences were not found for the additional sub-populations (Appendix K).

To examine if there were differences among elementary, middle, and high school teachers' beliefs regarding their classroom environment, an ANOVA was performed on the data collected from the CLES. Each test analyzed the sub-scales of the CLES, Personal Relevance, Mathematical Uncertainty, Critical Voice, Shared Control, and Student Negotiation.

The calculated data indicated that there were differences among teachers' beliefs about the CLES sub-scale, Personal Relevance. The differences occurred between elementary (K-5) and high (9-12) school teachers having a significance level of p =.001. Data analysis also revealed differences among the beliefs of middle and high school teachers about the sub-scale Personal Relevance. The significance level of p=.045 indicated that there was a statistically significant difference between middle and high school teachers' beliefs about the role of Personal Relevance in their classroom learning environment. Table 25 below contains the result of the ANOVA and a summary of the CLES sub-scale means for each school type for Personal Relevance.

Table 25.

ANOVA Results and Summary of Means for CLES Personal Relevance by School Type

K-12 Teachers	Sum of Squares	df	Mean Square	F	Sig. (p)
Between Groups	131.879	2	65.939	6.378	.002*
Within Groups	1674.933	162	10.339		
Total	1806.812	164			
School Type	Mean	SD			
Elementary	19.21	3.335			
Middle	18.59	2.935			
High School	16.37	2.948			

* p<0.05

The CLES sub-scale of Mathematical Uncertainty was analyzed using the data from K-12 mathematics teachers. This sub-scale reflects teachers' belief that their classroom learning environment provides opportunities for students to experience mathematics knowledge as evolving and being culturally and socially determined (Taylor, Fraser, & Fisher, 1993). Analysis of the data presented in Table 26 indicated that teacher' beliefs at the elementary, middle, and high school levels are not significantly different.

Table 26.

ANOVA Results for CLES Mathematical Uncertainty by School Type

K-12 Teachers	Sum of Squares	df	Mean Square	F	Sig. (p)
Between Groups	43.335	2	21.723	1.312	.272
Within Groups	2682.858	162	16.561		
Total	2726.303	164			

* p<0.05

The means from the CLES sub-scale, Critical Voice, range from 21.15 to 21.58. The relationship between the means for elementary, middle, and high school teacher survey data indicated that no significant differences were found in the CLES sub-scale, Critical Voice. In fact, the means among the three school levels showed similar mean totals. The results of the ANOVA are given below in Table 27.

Table 27.

ANOVA Results for CLES Critical Voice by School Type

K-12 Teachers	Sum of Squares	df	Mean Square	F	Sig. (p)
Between Groups	3.561	2	1.781	.148	.862
Within Groups	1942.887	162	11.993		
Total	1946.448	164			

* $p<0.05$

An analysis of Shared Control, the fourth sub-scale of the CLES, indicated that there were no significant differences in the sub-scale, Shared Control between elementary, middle, and high school teachers. The data analysis is shown below in Table 28.

Table 28.

ANOVA Results for CLES Shared Control by School Type

K-12 Teachers	Sum of Squares	df	Mean Square	F	Sig. (p)
Between Groups	58.913	2	29.456	1.604	.204
Within Groups	2975.900	162	18.370		
Total	3034.812	164			

* $p<0.05$

Teachers' beliefs about their classroom learning environment with regard to Student Negotiation were analyzed and revealed difference among elementary and high school teachers. The summary of data indicated significant differences existed between groups having a significance level of p = .033 however using addition analysis, the Tukey HSD, the significance level was greater than the significance level of 0.05. More specifically, Tukey analysis revealed differences among the beliefs of elementary and high school teachers at a significance level of p = .073. The data in Table 29 below summarizes the data.

Table 29.

ANOVA Results and Means for CLES Student Negotiation by School Type

K-12 Teachers	Sum of Squares	df	Mean Square	F	Sig. (p)
Between Groups	79.724	2	39.862	3.492	.033*
Within Groups	1849.404	162	11.416		
Total	1929.127	164			
School Type	**Mean**	**SD**			
Elementary	21.54	3.136			
High School	19.68	3.945			

* $p<0.05$

Additional analysis of the sub-populations, gender and education yielded significant results for CLES sub-scales. Results are located in Appendix L.

Summary

Examining the beliefs of Roberts County mathematics teachers (K-12) about the nature of mathematics and their classroom learning environment involved comparing mean totals for the TBS and CLES sub-scales, analyzing data using a Pearson correlation for the TBS and CLES sub-scales, and analyzing data using an ANOVA which determined differences among elementary, middle, and high school mathematics teachers.

The results indicated that teachers' beliefs were more consistent with the problem-solving view of mathematics and undecided about the instrumentalist view of mathematics. Additional findings indicated that among school type, elementary, middle, and high school teachers' beliefs about the nature of mathematics were consistent with one another. The sub-scales of the CLES (Personal Relevance, Mathematical Uncertainty, Critical Voice, Shared Control, and Student Negotiation) were also analyzed. The results indicated that K-12 mathematics teachers were in strong agreement with the sub-scales of Critical Voice and Student Negotiation and teachers were in agreement with the sub-scales of Personal Relevance and Shared Control. Survey data indicated that K-12 mathematics teachers were not in agreement with Mathematical Uncertainty. Differences among the three school types were found among the CLES sub-scales of Personal Relevance, Mathematical Uncertainty, Shared Control, and Student Negotiation.

The Pearson correlation results for teachers K-12 indicated that a positive correlation was found between the TBS sub-scale of problem-solving and all of the sub-scales of the CLES; however, there is a negative, non-significant correlation between the TBS sub-scale of an instrumentalist view of mathematics and the sub-scales of the CLES. Data analysis by school type indicated that there was a positive correlation between the CLES sub-scales and the problem-solving sub-scale of the TBS at the elementary level. Middle school data showed that only three of the CLES sub-scales, Critical Voice, Shared Control, and Student Negotiation positively correlated with the problem-solving sub-scale. High school mathematics teachers' data indicated no significant positive or negative correlation between the CLES sub-scales and the TBS sub-scales, problem-solving and instrumentalist views of mathematics.

The analysis of variance between elementary, middle, and high school teachers' TBS sub-scale means indicated that the TBS sub-scales of problem-solving and instrumentalist views of mathematics showed no significant difference among elementary, middle, and high school teachers. The CLES sub-scales were analyzed to find differences between elementary, middle, and high school teachers. The CLES sub-scales which yielded no significant differences among elementary, middle, and high school teachers' beliefs were Mathematical Uncertainty, Critical Voice, Shared Control, and Student Negotiation. The CLES subscale Personal Relevance was found to differ among elementary and high school teachers as well as middle and high school teachers.

CHAPTER 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This concluding chapter begins with a brief discussion of the study and a description of the Roberts County participants. Next, a discussion of findings with regard to the research questions and supporting literature are discussed. The final section of this chapter will provide conclusions and recommendations as a result of this study along with closing statements.

Summary of the Study

The purpose of this research study was to determine the relationship between kindergarten through twelfth grade mathematics teachers' beliefs regarding the nature of mathematics and their classroom learning environment in Roberts County. Researching beliefs was important because, as Mewborn and Cross (2007) note, "Teachers' beliefs about the nature of mathematics influence their beliefs about what it means to learn and do mathematics" (p.260). Not only does this research contribute to the larger body of teacher beliefs research, but the results of the research will help guide the researcher in making professional development decisions at the local level as Georgia is transitioning into a new mathematics curriculum.

Research for this study took place in Roberts County during Spring Semester 2008. Survey data were collected from kindergarten through twelfth grade mathematics teachers. The study involved 35 schools total: twenty elementary schools, nine middle schools, and six high schools.

The researcher used three surveys, the *Teacher Beliefs Survey* (TBS), *Constructivist Learning Environment Survey* (CLES), and a demographics survey to determine the beliefs of mathematics teachers (K-12) regarding the nature of mathematics and their classroom learning environment. The TBS survey, created by Beswick (2005), was used to determine teacher's beliefs about the nature of mathematics. The CLES measures teacher beliefs regarding their classroom learning environment (Taylor, Dawson & Fraser, 1995; Taylor, Fraser, & Fisher, 1997). The demographics survey included information which was necessary to divide the sample population into the sub-populations of gender, years of teaching experience, grade level taught, and highest degree earned.

Participants

This study involved surveying 300 elementary, middle, and high school mathematics teachers from thirty-five school in Roberts County. The stratified random sampling technique allowed the researcher to sample a subset of teachers that reflected the teacher population demographics of the county. The number of participants at each grade level closely reflected the overall population demographics of Roberts County. Additionally, of the thirty-five schools that participated in the study, at least one teacher from every school participated in the research study. Therefore, teacher demographics data from the returned surveys resemble Roberts County's overall teacher population data.

This study surveyed 300 participants from one school system which spanned from kindergarten to twelfth grade. Studies found by this researcher typically focused on one grade, teachers from a specific school type (elementary, middle, or high school), a school system, or multiple school systems. For example, Anderson (1998) surveyed only mathematics teachers (n=174) from twenty-one elementary schools Manouchehri and Goodman (1998) studied middle school teachers (n=66) from twelve different school districts. Cavanagh (2006) and Andrews and Hatch (1999) conducted high school teacher beliefs studies with participant sizes of 193 and 577 respectively. Sample size and grade level were also dependent on the type of research conducted. Beliefs research methods included case studies, observations, interviews, and surveys with small numbers of participants in studies by Thompson (1984), Grant and Kline (2001), and Nathan and Knuth (2003). Teacher beliefs studies that were similar in participant size by school type and that used survey data as a primary source included the elementary school study of Anderson (1998) with 174 participants and Beswick's (2005) study of 25 high school teachers. Therefore, this study will add to teachers' belief research because it looks holistically at a county setting involving elementary, middle school, and high school mathematics teachers.

Discussion of Findings

Three research questions addressed the beliefs of mathematics teachers, K-12, regarding the nature of mathematics and their classroom learning environment and the relationships of these beliefs.

Specifically, this study examined the following research questions:

1. What beliefs do mathematics teachers in Roberts County hold regarding:
    a. The nature of mathematics?

b. Their classroom learning environment?

2. Are there relationships between mathematics teachers' beliefs regarding the nature of mathematics and their classroom environment in Roberts County?
3. Are there differences between elementary, middle school, and high school mathematics teachers' beliefs regarding the nature of mathematics and their classroom learning environments in Roberts County?

Survey data to determine Roberts County's mathematics teachers' beliefs regarding the nature of mathematics and their classroom learning environment were described in the previous chapter. Findings from these surveys significant to the three research questions, with regard to relevant literature, are discussed in this section.

Research Question 1: What beliefs do mathematics teachers in Roberts County hold regarding:

a. The nature of mathematics?

b. Their classroom learning environment?

Roberts County, teachers K-12 completed the *Teacher Beliefs Survey* (TBS), *Constructivist Learning Environment Survey* (CLES), and a demographics survey that provided data and insight into teachers' beliefs about the nature of mathematics and their classroom learning environment.

Beliefs about the Nature of Mathematics

The TBS was used to determine the degree to which teachers have either a problem-solving or instrumentalist view of mathematics. The problem-solving (or constructivist) view of mathematics indicates that teachers' believe in the student's active construction of mathematics and that the teacher plays the role of facilitator (Ernest, 1989). The instrumentalist (or teacher-directed) view of mathematics includes skill, fact, and rule based instruction and teaching (Ernest, 1989). Research involving teachers' beliefs have found that the most common beliefs held by teachers are: 1) mathematics is computation, 2) the goal of mathematics is to obtain the correct answer, and 3) mathematics teaching in general should be teacher-centered (Frank, 1988). These types of beliefs are commonly associated with a teacher-directed (instrumentalist) view of mathematics.

Roberts County's K-12 mathematics teachers' (N=165) data showed that teachers agree with a problem-solving view of mathematics (m=60.37) and were undecided about beliefs regarding the instrumentalist view of mathematics (m=34.54), as shown in Chapter 4, Table 14. Kindergarten through twelfth grade mathematics teachers agreed with specific statements indicating their beliefs about the problem-solving nature of mathematics. Data supported that an important task for teaching mathematics involved motivating students to solve their own mathematical problems (TBS Statement 1). Additionally data indicated the importance of creating a safe, non-threatening environment for students to learn mathematics (TBS Statement 23). Survey statements with the highest mean totals for the TBS problem-solving subscale were presented in Chapter 4, Table 15.

At the elementary school level, data suggested that mathematics teaching involved motivating students to solve their own mathematical problems (TBS Statement 1, m=4.71). In research by Watson and De Geest (2005) mathematics teachers believed that a key part of learning mathematics was to help students develop intrinsic motivation towards solving mathematics problems. An important aspect of this mathematics learning was to make "inter-connections between different topics and representations," to make mathematics interesting, and to provide more opportunities for success (Watson & De Geest, 2005, p. 226).

Middle school teachers' survey data indicated that an important part of a problem-solving view of mathematics is for teachers themselves to enjoy learning and doing mathematics (TBS Statement 9, m=4.68). Middle school teachers, according to Williams and Baxter (1996) with regard to mathematics reform, recognized that student-centered (problem-solving) learning required them (teachers) to work the problems and participate in the activities given to their students and become a learner in the classroom too.

Mathematics teachers at the high school level believed that it was important to give students the opportunity to reflect and evaluate their own learning (TBS Statement 12, m=4.68). Additionally, survey data suggested that high school teachers found that an important aspect of mathematics was to know how to solve a problem, rather than to get the correct solution (TBS Statement 11, m=4.68). Roberts County high school mathematics teachers’ beliefs differed from those found by Nathan and Koedinger (2000) which determined that high school teachers tend to emphasize student mastery of procedures. Additionally, Nathan and Koedinger (2000) attribute the reliance of procedural teaching and avoidance of problem-solving on the teachers’ beliefs about the ability of their students to learn. The commentary provided in the *Georgia Performance Standards* for mathematics states: “There is a shift towards applying mathematical concepts and skills in the context of authentic problems and for the student to understand concepts rather than merely follow a sequence of procedures" (Georgia Department of Education, 2006, p. 1). Mathematics teachers in Roberts County have been undergoing training to implement the GPS for mathematics; professional development and the GPS documents emphasize teaching which allows students to apply concepts and skills.

The TBS data representing the twelve sub-scale statements for the instrumentalist view of mathematics for mathematics teachers (K-12) had a mean of 34.54, indicating that teachers were *Not Decided* (according to scale given in Chapter 4, Table 10). Two statements representing instrumentalist views of mathematics were in the range of *Strongly Agree* (SA=5) and *Agree* (A=4) according to the data analysis.

TBS statement seven, "It is important for teachers to understand the structured way in which mathematics concepts and skills relate to each other" (m=4.48) is one of the statements categorized by Beswick (2005) to reflect an instrumentalist view of mathematics. Statement twenty-one, "There is an established amount of content that should be covered at each grade level" (m=4.13) is also a statement categorized by Beswick (2005) to reflect an instrumentalist view of mathematics. Roberts County mathematics teachers are expected at the county level to follow the suggested pacing guide which outlines a timeline for teaching Georgia's mathematics curriculum, provided by the Georgia Department of Education.

Statements 7 and 21 were both influenced by county and state curricular expectations. Responses by mathematics teachers in Beswick's (2005) study were similar for those two statements of the TBS. Beswick (2005) concluded that the agreement of teachers with these statements may be "a function of a range of contextual variables" (p. 51). Williams and Baxter (1996) noted often teachers are "bound both legally and ethically to help students gain the knowledge skills, understanding, or concepts that characterize" mathematical competence for a particular grade level (p. 23).

Roberts County mathematics teachers beliefs about the nature of mathematics, as indicated by the TBS, reflects the problem-solving view of mathematics. With regard to the problem-solving view of mathematics however there are many factors, as Thompson (1984) found, that interact with teachers' beliefs. For Roberts County teachers, variables which may effect beliefs about the nature of mathematics are: a structured state and county curriculum, curricular expectations to integrate mathematics concepts as opposed to teaching concepts and skills as procedures, and mandated state curricular mathematics testing.

Beliefs about Their Classroom Learning Environment

The *Constructivist Learning Environment Survey* (CLES) determined the degree to which teachers agreed with the five sub-scales of Personal Relevance, Mathematical Uncertainty, Critical Voice, Shared Control, and Student Negotiation. Each sub-scale is characteristic of a constructivist learning environment as defined by Taylor, Fraser, and Fisher (1997). In comparison to the TBS, mathematics teachers are evaluating their level of agreement with each statement based upon their mathematics classroom learning environment.

Of the CLES sub-scales, Roberts County mathematics teachers' survey data indicated that their classroom learning environments most closely reflected the sub-scales of Critical Voice (m=21.43) and Student Negotiation (m=21.07). Classroom learning environments which reflect the ideals of Critical Voice have a social climate whereby students may question or voice feelings about the content, activities, or about their own learning (Taylor, Fraser, and Fisher, 1997). Student Negotiation, the opportunity for students to communicate through explanation and justification while also allowing for student reflection of their own and others ideas, was another aspect that data indicated was reflected in their classroom learning environment (Taylor, Fraser, and Fisher, 1997). A summary of CLES sub-scale mean totals are presented in Chapter 4, Table 19. Roberts County's mathematics teachers' level of agreement with the statements from the sub-scales Critical Voice and Student Negotiation shows that teachers value a classroom learning environment that supports communication. Of the "five shifts" suggested in the *Professional Standards for Teaching Mathematics* (PSTM), a classroom environment which supports "classrooms as mathematical communities" as opposed to "a collection of individuals" is an important aspect of the classroom learning environment (NCTM, 1991, p.2). Clarke (1997) collected a list of components and beliefs that were common among mathematics classrooms which promoted a student-centered classroom environment. Among the components listed was the development of a mathematical community which developed from teachers' beliefs which supported that "an atmosphere of conjecture and justification of mathematical ideas enhances learning" (Clarke, 1997, p. 280).

An aspect of the classroom learning environment survey that Roberts County teachers did not agree with is the CLES sub-scale, Mathematical Uncertainty. This sub-scale includes exposing students to the fact that mathematical knowledge is evolving and culturally and socially influenced. Each school type, elementary (m=12.49), middle (m=13.41), and high school (m=11.58) teachers mean scores were similar to one another for this sub-scale of the CLES. Cavanaugh's (2006) research determined that teacher's strongly believed that "mathematical knowledge is immutable", therefore that is the way mathematics ought to be taught, which influences the classroom learning environment (p. 119). Grant and Kline (2001) found that although mathematics teachers may have beliefs which are student-centered (problem-solving) and encourage problems to be solved through a variety of methods, the mathematics teacher is still the "clear authority on the correctness of solutions" (p. 695). This study supports this assertion.

Roberts County mathematics teachers do not support all aspects of a constructivist learning environment, as shown by the CLES survey data (Appendix N). The data analysis of the CLES determined teachers' level of agreement with each statement based upon their classroom learning environment. Research about teachers' views of their mathematics classroom learning environment, using the CLES, are not prevalent in classroom learning environment literature. The study most closely related to this study is Beswick's

(2004) study that explored a two mathematics teachers' perceptions of their classroom learning environment. Her findings revealed that although the mathematics teachers held a problem-solving view of mathematics, the extent to which they agreed with the CLES sub-scale items varied (Beswick, 2004). Beswick (2004) along with other researchers have theorized that beliefs are not always observable in classroom practice (Ernest, 1989; Thompson, 1992).

Research Question 2: Are there relationships between mathematics *teachers' beliefs regarding the nature of mathematics and their classroom learning environment in* Roberts County?

To examine the relationship between teachers' beliefs regarding the nature of mathematics and their classroom learning environment TBS sub-scales and CLES sub-scales were correlated for all kindergarten through high school mathematics teachers and by school type, elementary, middle, and high school. The correlational data determined whether or not significant relationships between teachers' beliefs about the nature of mathematics and teachers' beliefs about their classroom learning environment existed.

Data analysis revealed that for each sub-scale of the CLES (Personal Relevance, Mathematical Uncertainty, Critical Voice, Shared Control, and Student Negotiation) and the TBS sub-scale, problem-solving, a significant, positive correlation existed. There were no significant positive or negative correlations between the TBS sub-scale instrumentalist and the CLES sub-scales (Chapter 4, Table 21).

Mathematics teachers by the sub-population school type were also analyzed to determine the relationships between beliefs about the nature of mathematics and beliefs about their classroom learning environment. Elementary school teachers' data showed that significant, positive correlations existed among the TBS sub-scale problem-solving and all of the CLES sub-scales, whereas high school teachers' data showed no significant positive or negative correlation between the TBS and CLES sub-scales (Chapter 4, Table 22). In relation to their (elementary teachers) problem-solving view of mathematics, elementary mathematics teachers' beliefs about the nature of mathematics and their classroom learning environment show a stronger correlation to one another than do the beliefs of middle and high school mathematics teachers. Middle school teachers' data differed from both the elementary and high school data. For the middle school teachers' data, a significant negative correlation existed between the TBS sub-scale instrumentalists and the CLES sub-scale Mathematical Uncertainty; however, data for the middle school teachers' revealed a significant, positive correlation between the TBS sub-scale problem-solving and the CLES sub-scales of Student Negotiation, Shared Control, and Critical Voice.

A positive significant relationship between the CLES sub-scales and the TBS sub-scale problem-solving indicate that Roberts County mathematics teachers' beliefs about the nature of mathematics may influence their beliefs about their classroom environment for the entire sample, K-12. However, data analysis indicates that differences among these relationships vary among the school types for elementary, middle, and high school teachers. Thus, inconsistencies at the middle and high school levels about these relationships between beliefs may indicate that the relationship between teachers' beliefs about the nature of mathematics and their classroom learning environment is a complex one (Charalambous, Philippou, & Kyriakides, 2002; Thompson, 1984). Related research supports that the relationship between teachers' beliefs about the nature of mathematics and their classroom learning environment may be attributed to the "social context, constraints and affordances of the learning environment, the beliefs and expectations of others in the educational process (student, parents, administrators, and policymakers), and the philosophical structure of the educational system" (Mewborn & Cross, 2007, p. 261; Thompson, 1992; Ernest, 1989). Raymond (1997) in looking at elementary school mathematics teachers' beliefs and practices determined that there are four main causes of inconsistency with regard to beliefs and practice. These are: 1) time constraints, 2) scarcity of resources, 3) concerns over standardized testing, and 4) students' behaviors (Raymond, 1997, p. 567).

Research Question 3: Are there differences between elementary, middle, and high school mathematics teachers' beliefs regarding the nature of mathematics and their classroom learning environments?

An Analysis of Variance (ANOVA) was used to determine the differences among Roberts County elementary, middle, and high school mathematics teachers regarding the nature of mathematics and their classroom learning environment. Statistically significant differences were analyzed further to determine which school types differed.

Beliefs about the Nature of Mathematics

The comparison of teachers' beliefs regarding the nature of mathematics examined the differences in mean values of elementary, middle, and high school teachers for the TBS sub-scales of the problem-solving and instrumentalist views of mathematics. The ANOVA results showed that teachers of each school type did not differ significantly in either the problem-solving ($p=.275$) or instrumentalist ($p=.062$) views of mathematics. Mathematics teachers beliefs, K-12, regarding the nature of mathematics are similar to one another (Chapter 4, Tables 23 and 24).

Beliefs about their Classroom Learning Environment

In comparing teachers' beliefs regarding their classroom learning environment, each of the sub-scale (Personal Relevance, Mathematical Uncertainty, Critical Voice, Student Negotiation, and Shared Control) means were compared to one another by school type. Data analyzed for the CLES sub-scale, Personal Relevance, showed that elementary, middle, and high school teachers vary significantly in their beliefs, according to the data, about the role of Personal Relevance in their classroom learning environment ($p=.002$) (Chapter 4, Table 25). Personal Relevance, which measures the extent to which teachers connect school mathematics to students' out of school experiences, did not have a high level of agreement from high school teachers (Taylor, Fraser, & Fisher, 1997). Among the three school types, elementary school teachers had the highest mean for the sub-scale Personal Relevance. The ANOVA determined statistically significant differences among elementary and high school mathematics teachers ($p=.001$), as well as middle and high school mathematics teachers ($p=.045$), where significance is $p<0.05$. Therefore, it can be concluded that elementary, middle, and high school teachers have varying beliefs about the role of Personal Relevance in their classroom learning environment. Middleton (1999) conducted a case study of two middle school mathematics teachers undergoing curricular change. The teachers involved in Middleton's (1997) study reported an important aspect in teaching and building student's confidence was to provide practical applications of the content with connections to the students' interests. Roberts County mathematics teachers K-12 are currently going through mathematics curriculum changes, but are following different timelines with regard to implementation. Grades K-8 during this study had completely the new curriculum, whereas grades 9-12 were currently undergoing training. Data from this study may suggest that grades K-8 found that making connections between the content and student’s outside school interests was a way to engage students in learning. Another factor important to consider is the emphasis of the GPS for mathematics Process Standard which states that “Students will make connections among mathematical ideas and to other disciplines by recognizing and applying mathematics in contexts outside of mathematics (Georgia Department of Education, 2006, p. 17).

The CLES sub-scale Mathematical Uncertainty determines the extent that teachers provide students the opportunities to see mathematics as evolving and being culturally and socially determined. Data results for teachers at each school showed a low level of agreement with the sub-scale Mathematical Uncertainty, ranging from 11.58 to 13.41. In comparison with one another, elementary, middle, and high school teachers did not show any significant differences ($p=.272$) in their belief about the role of Mathematical Uncertainty (Chapter 4, Table 26). Similar to Mathematical Uncertainty, the ANOVA results for the sub-scale, Critical Voice, did not vary significantly among the three school types ($p=.862$) (Chapter 4, Table 27). The CLES sub-scale Critical Voice was a sub-scale that Roberts County teachers’ overall felt was an important part of their classroom learning environment.

Survey data, which compared elementary, middle, and high school beliefs of their classroom learning environment, revealed that Roberts County mathematics teachers differed about the role of Student Negotiation in their classroom learning environment. The CLES sub-scale Student Negotiation had the highest mean total among each of the three school types with means of 21.54, 20.32, and 19.68, respectively. However, according to ANOVA results, there was a statistically significant difference among elementary and high school teachers ($p=.033$) with regard to Student Negotiation (Chapter 4, Table 28). As with the CLES sub-scale Personal Relevance, elementary mathematics teachers' beliefs regarding Student Negotiation may have been influenced by the GPS for mathematics. The GPS Process Standards for mathematics emphasizes communicating and justifying mathematics through student and teacher interactions. As Middleton (1999) found in his study, "teachers' practices shifted to accommodate the requirements" is the changed curricular materials (p. 352).

Although Roberts County teachers did not agree to the same extent about the role of Shared Control in their classroom learning environment, the CLES sub-scale comparisons among school type did not show any significant differences ($p=.204$). Shared Control is the extent to which students, along with the teacher, are able to determine their learning goals, learning activities, and assessment.

Similarities in mean scores among Roberts County mathematics teachers K-12 with regard to the problem-solving and instrumentalist views of mathematics were not statistically significant enough between grade levels to reveal differences. Due to the consistencies among the means of Mathematical Uncertainty, Shared Control, and Critical Voice, no statistically significant differences among elementary, middle, and high school teachers could be found. The means of Personal Relevance and Student Negotiation showed inconsistencies among elementary, middle, and high school data resulting in statistically significant ANOVA results between the school types.

Literature relative to the findings in Roberts County's K-12 mathematics teachers' data with regard to the TBS and CLES surveys were not found to contribute to this study. However supporting literature about teachers' beliefs, practices, and implementation of curricular materials provided insight into the findings of this study. Literature suggests that differences among grade levels or inconsistencies among school types can be attributed to educational influences (administration, standardized testing, etc.), student behaviors, and curricular materials

(Mewborn & Cross, 2007; Raymond, 1999; Thompson, 1992; Ernest, 1989).

Data generated as a result of research about kindergarten through twelfth grade teachers in Roberts County contributes to research about mathematics teachers' beliefs regarding the nature of mathematics and their classroom learning environment. This research data provides a comparison of these beliefs for mathematics teachers at the elementary, middle, and high school levels.

Conclusions

Research about Roberts County K-12 mathematics teachers has provided a basis with which to begin understanding the relationship between teachers' beliefs regarding the nature of mathematics and their classroom learning environment. Results from this study have provided the following conclusions about the relationship between teachers' beliefs and their classroom learning environment.

The first conclusion is that mathematics teachers K-12 hold beliefs consistent with the problem-solving view of mathematics and undecided about the instrumentalist's view of mathematics. However, the levels to which teachers hold these beliefs vary. Roberts County mathematics teachers K-12 have a higher or stronger proclivity to the statements which support the problem-solving view of mathematics.

Select statements which support an instrumentalist’s view of mathematics are also important to K-12 mathematics teachers as well. These findings support that teachers have beliefs which support both of these facets of the nature of mathematics, which disallows categorizing teachers as problem-solving or instrumentalist.

Second, the relationship between mathematics teachers’ beliefs about problem-solving versus instrumentalist views of mathematics cannot be viewed as an “either/or” scenario. The aforementioned claims that mathematics teachers can hold beliefs which support both problem-solving and instrumentalists views of mathematics need to be studied further. Clarifying data needs to be collected to better understand why teachers regard aspects of an instrumentalist’s view of mathematics as being important to their beliefs about the nature of mathematics. From other research studies a variety of contextual variables have been shown to account for differences or inconsistencies in teachers’ beliefs.

Third, mathematics teachers’ support learning environments that include communication and reflection among students and teachers, as well as a social climate that allows students to question their methods of learning. Roberts County teacher data supports that teachers value these aspects of their classroom learning environment. The *Georgia Performance Standards* for mathematics and the *Principles and Standards for Teaching Mathematics* also support these aspects of the classroom learning environment.

A fourth conclusion from this study is that a relationship exists, albeit small, between Roberts County mathematics teachers' beliefs about the nature of mathematics and their classroom learning environment. This relationship is important because it provides additional data to support the relationship between teachers' beliefs about the nature of mathematics and their classroom learning environment. Supporting literature shows that the degree to which beliefs and practices varies, however, the relationship between beliefs and practice does exist (Beswick, 2005; Watson & De Geest, 2005; Thompson, 1992; Ernest 1989).

Fifth, the extent which Roberts County teachers' beliefs about the nature of mathematics and their classroom learning environment varies among elementary, middle, and high school mathematics teachers. Data supports that teachers from varying school types have differences in the degree to which these beliefs are held in relation to one another. This data is important because it provides data derived from a common set of survey instruments to analyze teacher beliefs and their classroom learning environment. Literature with regard to mathematics teachers' beliefs according to school type and in comparison to one another could not be found for a single school system, K-12. Data from this study provides a way to analyze and look at the differing needs of teachers which can provide staff development to meet the needs of each grade type.

Recommendations

Research about Roberts County mathematics teachers K-12 has provided data about teachers' beliefs regarding the nature of mathematics and their classroom learning environment. Using this data, a goal of this study was meeting the expectations of the *National Council of Teachers of Mathematics* (NCTM) and the *Georgia Performance Standards* (GPS) for mathematics. Research data provided the researcher with preliminary data to make the following recommendations in order to move Roberts County mathematics teachers of each school type towards NCTM and GPS expectations.

To impact professional learning in Roberts County, the data relevant to this study should be discussed and analyzed by mathematics coaches for the county. Data from the study should be presented by the researcher in a manner to help colleagues understand the findings of the study. Professional learning in mathematics for each school type should consider the findings of the study as professional development courses are being discussed and planned. Professional learning may focus on specific areas from the survey data which were low in level of agreement or build upon the strengths found within K-12 mathematics teachers or teachers at each school type.

At the county level, mathematics supervisors for K-6 and 6-12 should be presented the data relevant to this study. The data should be discussed and analyzed by Roberts County's mathematics supervisors to provide them with insight into the relationship between teachers' beliefs and their classroom learning environment. The K-6 and 6-12 coordinators need to become mindful of the relationship between teacher beliefs and teacher practices in Roberts County as well as through supporting literature. A more thorough understanding about the relationship between beliefs and practices could impact the type and length of support provided to mathematics teachers to implement the Georgia Performance Standards for mathematics. Supporting research suggests that ongoing support is needed for mathematics teachers. Research supports the notion that to change or shift their (teachers) beliefs and/or their classroom learning environments, ways for teachers to reflect on their own beliefs and practices must be provided (Thompson, 1992).

Lastly, school administrators need to be informed and be aware of the usefulness of having teachers examine their own beliefs about the nature of mathematics and their classroom learning environment. A way to do this may be to have teachers and students fill out similar surveys about mathematics teaching, and or classroom learning environments. For example, the *Constructivist Learning Environment Survey* (CLES) has a student version as well as a teacher version. Data collected from the two surveys would provide a way to evaluate and compare student and teacher perceptions regarding their classroom learning environment. This may be one way to improve the classroom learning environment to benefit both the teachers and the students.

Suggestions for Further Research

There is much to be learned about the beliefs of Roberts County mathematics teachers regarding their beliefs about the nature of mathematics and their classroom learning environment. The present study provided answers to the research questions presented in this study however, the data generated brought about more questions which need to be asked with regard to teachers' beliefs and their classroom learning environments. As suggested by Wilson and Cooney (2002), "questionnaire responses represent dispositions to respond to a written stimulus, but they do not constitute strong evidence of what an individual might do when interacting in the classroom" (p. 145).

The analysis of data provided the researcher a rationale to dig deeper. At the local level, teachers who participated in the original study could be selected to elaborate or explain responses to specific survey items which need clarification beyond the data. In addition to interviews, classroom observational data could be collected to gain a different perspective of the teachers' beliefs about their classroom learning environment. As stressed from mathematics researchers, a variety of research methods needs to be employed to gain a complete understanding of the relationships between beliefs about the nature of mathematics and their classroom learning environment (Wilson & Cooney, 2002; Thompson, 1992).

At the state or national level more research of this type needs to be conducted to compare the differences between school types with regard to teachers' beliefs and their classroom learning environment. Studies at specific grade levels or with particular schools have been conducted, however, the same types of surveys or research instrumentation needs to applied to a collection of teachers ranging from kindergarten through twelfth grade. This type of research involving all grade levels concerning mathematics could not be found by this researcher.

Mathematics literature, as well as this study, supports the existence of a relationship between mathematics teacher beliefs' regarding the nature of mathematics and their classroom learning environment (Mewborn & Cross, 2007; Beswick, 2006; Wilson & Cooney, 2002; Thompson, 1992; Ernest, 1989). The purposes for conducting teacher beliefs research varies among the literature. However, "if our goal is to improve students' learning of mathematics, we must begin the discussion with a focus on teachers, since they will ultimately have the greatest impact on the development of future mathematicians, their understanding, and their subsequent achievement" (Mewborn & Cross, 2007, p. 268).

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APPENDICES

APPENDIX A

PARTICIPANT SAMPLING BY SCHOOL LEVEL AND SCHOOL

Roberts County Elementary Schools by ID #	# of Teachers That Teach Mathematics	# of Participants Selected (N=225)
1-E	33	11
2-E	29	11
3-E	25	11
4-E	43	13
5-E	30	11
6-E	25	11
7-E	29	11
8-E	23	11
9-E	23	11
10-E	33	11
11-E	30	11
12-E	23	11
13-E	28	11
14-E	33	11
15-E	37	12
16-E	38	13
17-E	29	11
18-E	31	11
19-E	19	11
20-E	28	11

Roberts County Middle Schools by ID #	# of Teachers That Teach Mathematics	# of Participants Selected (N=45)
1-M	14	5
2-M	3	3
3-M	10	4
4-M	14	5
5-M	11	4
6-M	15	6
7-M	17	6
8-M	16	6
9-M	15	6

Roberts County High Schools by ID #	# of Teachers That Teach Mathematics	# of Participants Selected (N=30)
1-H	2	2
2-H	1	1
3-H	23	8
4-H	23	8
5-H	9	4
6-H	22	7

APPENDIX B

TEACHER BELIEFS SURVEY

Place a check in the box that describes your level of agreement with each statement.

Beliefs About Mathematics, Its Teaching, and Its Learning						
Items:		Strongly Agree (5)	Agree (4)	Not Decided (3)	Disagree (2)	Strongly Disagree (1)
1	A vital task for the teacher is motivating children to solve their own mathematical problems.					
2	Mathematics is computation.					
3	Ignoring the mathematical ideas that children generate themselves can seriously limit their learning.					
4	Children always benefit by discussing their solutions to mathematical problems with each other.					
5	It is important for children to be given opportunities to reflect on and evaluate their learning.					
6	Allowing a child to struggle with a mathematical problem, even a little tension, can be necessary for learning to occur.					
7	It is important for teachers to understand the structured way in which mathematics concepts and skills relate to each other.					
8	Mathematics is a beautiful, creative, and useful human endeavor that is both a way of knowing and a way of thinking.					

Items:		Strongly Agree (5)	Agree (4)	Not Decided (3)	Disagree (2)	Strongly Disagree (1)
9	Effective mathematics teachers enjoy learning and doing mathematics themselves.					
10	Providing children with interesting problems to investigate in small groups is an effective way to teach mathematics.					
11	Knowing how to solve a mathematics problem is as important as getting the correct solution.					
12	Teachers of mathematics should be fascinated with how children think and intrigued by alternative ideas.					
13	Persistent questioning has a significant effect on children's mathematical learning.					
14	If a child's explanation of a mathematical solution doesn't make sense to the teacher it is best to ignore it.					
15	Telling the children the answer is an efficient way of facilitating their mathematics learning.					

Items:		Strongly Agree (5)	Agree (4)	Not Decided (3)	Disagree (2)	Strongly Disagree (1)
16	It is important that mathematics content be presented to children in the correct sequence.					
17	Justifying the mathematical statements that a person makes is an extremely important part of mathematics.					
18	It is important to cover all the topics in the mathematics curriculum in the textbook sequence.					
19	I would feel uncomfortable if a child suggested a solution to a mathematical problem that I hadn’t thought of previously.					
20	As a result of my experience in mathematics classes, I have developed an attitude of inquiry.					
21	There is an established amount of mathematical content that should be covered at each grade level.					
22	Mathematical material is best presented in an expository style: demonstrating, explaining, and describing concepts and skills.					

Items:		Strongly Agree (5)	Agree (4)	Not Decided (3)	Disagree (2)	Strongly Disagree (1)
23	Teachers can create, for all children, a non-threatening environment for learning mathematics.					
24	It is not necessary for teachers to understand the source of children's errors; follow-up instruction will correct their difficulties.					
25	Listening carefully to the teacher explaining a mathematics lesson is the most effective way to learn mathematics.					
26	It is the teacher's responsibility to provide children with clear and concise solution methods for mathematical problems.					

APPENDIX C

CONSTRUCTIVIST LEARNING ENVIRONMENT SURVEY

Constructivist Learning Environment Survey

What happens in my mathematics classroom?

• Teacher form •

DIRECTIONS

1. **Purpose of the Questionnaire**
   This questionnaire asks you to describe important aspects of the mathematics classroom which you are in right now. There are no right or wrong answers. Your perspective is what is wanted. Your answers will enable us to improve future mathematics teaching.

2. **How to Answer Each Question**
   On the next few pages you will find 30 sentences. For each sentence, circle only one number corresponding to your answer. For example:

		Almost Always	Often	Some-times	Seldom	Almost Never
In this class . . .						
8	I ask the students questions	5	4	3	2	1

- If you think that you *almost always* ask the students questions, circle the 5.
- If you think that you *almost never* ask the students questions, circle the 1.
- Or you can choose the number 2, 3 or 4 if one of these seems like a more accurate answer.

3. **How to Change Your Answer**
   If you want to change your answer, cross it out and circle a new number, For example:

8	I ask the students questions.	~~5~~	4	3	2	1

4. **Completing the Questionnaire**
   Now turn the page and please give an answer for every question.

Learning about the world	Almost Always (5)	Often (4)	Some-times (3)	Seldom (2)	Almost Never (1)
In this class . . .					
1 Students learn about the world outside of school.	5	4	3	2	1
2 Students' new learning starts with problems about the world outside of school.	5	4	3	2	1
3 Students learn how mathematics can be part of their out-of-school life.	5	4	3	2	1
In this class . . .					
4 Students get a better understanding of the world outside of school.	5	4	3	2	1
5 Students learn interesting things about the world outside of school.	5	4	3	2	1

Learning about mathematics	Almost Always (5)	Often (4)	Some-times (3)	Seldom (2)	Almost Never (1)
In this class . . .					
6 Students learn that mathematics has changed over time.	5	4	3	2	1
7 Students learn that mathematics is influenced by people's values and opinions.	5	4	3	2	1
In this class . . .					
8 Students learn about the different mathematics used by people in other cultures.	5	4	3	2	1
9 Students learn that modern mathematics is different from the mathematics of long ago.	5	4	3	2	1
10 Students learn that mathematics is about <u>inventing</u> rules.	5	4	3	2	1

Learning to speak out	Almost Always (5)	Often (4)	Some-times (3)	Seldom (2)	Almost Never (1)
In this class . . .					
11 It's OK for students to ask me "why do I have to learn this?"	5	4	3	2	1
12 It's OK for students to question the way I'm teaching.	5	4	3	2	1
13 It's OK for students to complain about activities that are confusing.	5	4	3	2	1
In this class . . .					
14 It's OK for students to complain about anything that prevents them from learning.	5	4	3	2	1
15 It's OK for students to express their opinions.	5	4	3	2	1

Learning to learn	Almost Always (5)	Often (4)	Some-times (3)	Seldom (2)	Almost Never (1)
In this class . . .					
16 Students help me to plan what they're going to learn.	5	4	3	2	1
17 Students help me to decide how well they are learning.	5	4	3	2	1
18 Students help me to decide which activities are best for them.	5	4	3	2	1
In this class . . .					
19 Students help me to decide how much time they spend on activities.	5	4	3	2	1
20 Students help me to decide which activities they do.	5	4	3	2	1

Learning to communicate	Almost Always (5)	Often (4)	Some-times (3)	Seldom (2)	Almost Never (1)
In this class . . .					
21 Students get the chance to talk to other students.	5	4	3	2	1
22 Students talk with other students about how to solve problems.	5	4	3	2	1
23 Students explain their ideas to other students.	5	4	3	2	1
In this class . . .					
24 Students ask other students to explain their ideas.	5	4	3	2	1
25 Students ask each other to explain their ideas.	5	4	3	2	1

CLES, Taylor & Fraser, Curtin University, Nov 1993

APPENDIX D

DEMOGRAPHICS SURVEY

DEMOGRAPHIC INFORMATION SHEET

Please mark or fill in the appropriate responses:

1. I am ___ female ___ male.

2. My highest degree earned is:

   ___ bachelor's ___ master's ___ 6-year ___ doctorate

3. I am in my ___ year of teaching. (Please include this year.)

4. I currently teach mathematics in grade(s):

   ___ K ___ 1 ___ 2 ___ 3 ___ 4 ___ 5

   ___ 6 ___7 ___ 8 ___ 9-12

APPENDIX E

INTERNATIONAL REVIEW BOARD PERMISSION LETTER

GEORGIA SOUTHERN UNIVERSITY
OFFICE OF RESEARCH SERVICES & SPONSORED PROGRAMS
POST OFFICE BOX 8005
STATESBORO, GEORGIA 30460-8005
TELEPHONE: (912) 681-5465

May 9, 2007

Elizabeth P. Brechin-Harrison
109 Devereaux Dr.
Perry, GA-31069

Dear Elizabeth P. Brechin-Harrison,

After a review of your proposed research project numbered: **H07225**, and titled **"Examining Mathematics Teacher's Beliefs Regarding the Nature of Mathematics, Mathematics Teaching, and Mathematics Learning"**, it appears that your research involves activities that do not require approval by the Institutional Review Board according to federal guidelines.

According to the Code of Federal Regulations Title 45 Part 46, your research protocol is determined to be exempt under the following exemption category(s):

> Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (I) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (II) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

Therefore, as authorized in the Federal Policy for the Protection of Human Subjects, I am pleased to notify you that your research is exempt from IRB approval. You may proceed with the proposed research.

Sincerely,

N. Scott Pierce

N. Scott Pierce
Director of Research Services and Sponsored Programs

APPENDIX F

ADMINISTRATIVE PERMISSION LETTER

August 10, 2007

Dear Principal:

I am conducting a research study as a part of my Ed.D program in Curriculum Studies at Georgia Southern University. This letter is to request your permission to conduct a research study with mathematics teachers in your school.

The research study consists of three surveys that may each take 5-7 minutes to complete.

The purpose of this study is to examine mathematics teacher's beliefs about the nature of mathematics and the teacher's perceptions of their classroom learning environment. The completion of the survey will be considered permission to use each teacher's results in the study. The data will remain confidential and will be destroyed after the necessary data is collected. In no way can individual respondents be identified in the study.

Thank you for your thoughtful participation. Please feel free to contact me if you have any questions about the surveys. My contact information is: home, 478-9xx-xxxx or cell, 478-3xx-xxxx. My email address is eharrison@hcbe.net.

If you have any questions or concerns about the rights of the participants in this study, you may contact Georgia Southern University, Institutional Review Board, 912-681-5205.

Respectfully,

Elizabeth Brechin-Harrison

APPENDIX G

COUNTY LEVEL RESEARCH APPROVAL

M E M O R A N D U M

DATE: November 14, 2007

TO: Elizabeth Brechin-Harrison

FROM: James H. Kinchen,
Assistant Superintendent for School Operations

SUBJECT: **EDUCATIONAL STUDY**

Your request to use data from two surveys as well as a demographics survey among elementary, middle, and high school mathematics teachers that you will conduct for your research study is approved.

Thank you for the data breakdown regarding principals' approval, and for the assurance that all data will remain confidential.

Please keep in mind that the Central Office Department of Testing is unable to compile data for you for your research.

Good luck with completing your doctorate degree. Please let me know if I may be of any assistance to you again in the future.

JHK: jm

APPENDIX H

PRINCIPAL’S FOLLOW-UP PROCEDURES LETTER

Dear Principal:

In August 2007, you granted permission for me conduct survey research with the teachers in your school. The purpose of the research is to determine whether there is a relationship between teachers' beliefs about the nature of mathematics and their classroom learning environment.

I would like to conduct the research over the next few weeks. Here is a summary of the research process:

1. I will deliver the surveys to your school. The teachers chosen for the survey will be chosen randomly. No more than 11 teachers will be surveyed from your school.
2. I will distribute the surveys by placing an envelope in each of the selected teacher's boxes. Inside the envelope is a cover letter explaining the purpose of the survey, the 3 surveys, and a self-addressed stamped envelope for the teacher to drop into the mail. The teachers' surveys will be coded to protect each participant's identity.

I have attached the cover letter that will be inside the envelope.

I am making every effort to conduct this research so that the participating teachers' identities are protected. If you have any questions or concerns, please feel free to contact me at (478)3XX-XXXX. The research protocol has been approved through Mr. James Kinchen.

Again, thank you for your participation in this research study.

Best Regards,

Elizabeth Brechin-Harrison

APPENDIX I

PARTICIPANT FOLLOW-UP LETTER

Dear Participant,

Three weeks ago, you received three surveys for research that I am conducting with K-12 Mathematics teachers. The survey research data that I gather will be used to complete my dissertation at Georgia Southern University to receive my doctorate.

My goal is to receive at least 50% of the surveys out of 300 packets that I delivered to each of the schools.

If you would still like to participate, please mail the survey forms using the self-addressed stamped envelope provided in the packet.

I would appreciate your support and participation. Thank you!

*Please disregard if you have already sent the materials.

Best Regards,

Elizabeth Brechin-Harrison

APPENDIX J

DETAILED PARTICIPANT DEMOGRAPHICS DATA

Gender

Gender	Number of Participants by Gender	Percent of Participants by Gender based on Total (N=165)
Male	25	15.2%
Female	140	84.8%

Highest Degree Earned

Type of Degree	Number of Participants by Highest Degree Earned	Percent of Participants by Highest Degree based on Total (N=165)
Bachelors	52	31.5%
Masters	82	49.7%
Specialists	31	18.8%

Number of Years Teaching Experience

Years of Teaching Experience	Number of Participants by Years Teaching of Experience	Percent of Participants by Years Teaching of Experience based on Total (n=165)
1-5	50	30.3%
6-10	36	21.8%
11-15	31	18.8%
16-20	25	15.2%
21-25	10	6.0%
26-30	6	3.7%
31+	7	4.2%

APPENDIX K

TEACHER BELIEFS SURVEY RESULTS BY ADDITIONAL SUB-POPULATIONS

Sub-scale Mean Totals for the TBS by Gender

Problem-solving View of Mathematics					
Gender	N	Min. Score	Max. Score	Mean	SD
Male	25	50	67	59.28	4.267
Female	140	47	70	60.56	5.354

Instrumentalist View of Mathematics					
School Type	N	Min. Score	Max. Score	Mean	SD
Male	25	29	43	34.88	3.689
Female	140	22	60	34.48	4.949

Sub-scale Mean Totals for the TBS (Problem-Solving) by Education

Problem-solving View of Mathematics					
Education	N	Min. Score	Max. Score	Mean	SD
Bachelor's	52	50	70	59.98	4.518
Master's	82	47	70	60.17	5.481
Specialists	31	49	70	61.55	5.561

Sub-scale Mean Totals for the TBS (Instrumentalist) by Education

Instrumentalists View of Mathematics					
Education	N	Min. Score	Max. Score	Mean	SD
Bachelor's	52	24	43	35.06	4.290
Master's	82	22	43	34.41	4.433
Specialists	31	27	60	34.00	6.272

ANOVA Results for TBS (Problem-solving) by Gender

Gender	Sum of Squares	df	Mean Square	F	Sig. (p)
Between Groups	34.987	1	34.987	1.290	.258
Within Groups	4421.461	163	27.126		
Total	4456.448	164			

ANOVA Results for TBS (Instrumentalist) by Gender

Gender	Sum of Squares	df	Mean Square	F	Sig. (p)
Between Groups	3.418	1	3.418	.149	.700
Within Groups	3731.576	163	22.893		
Total	3734.994	164			

ANOVA Results for TBS (Problem-solving) by Education

Gender	Sum of Squares	df	Mean Square	F	Sig. (p)
Between Groups	54.181	2	27.090	.997	.371
Within Groups	4402.268	162	27.174		
Total	4456.448	164			

ANOVA Results for TBS (Instrumentalist) by Education

Gender	Sum of Squares	df	Mean Square	F	Sig. (p)
Between Groups	24.265	2	12.132	.530	.590
Within Groups	3710.729	162	22.906		
Total	3734.994	164			

APPENDIX L

CONSTRUCTIVIST LEARNING ENVIRONMENT SURVEY

RESULTS BY ADDITIONAL SUB-POPULATIONS

Sub-scale Mean Totals for the CLES Sub-scales by Gender

Personal Relevance

Gender	N	Min. Score	Max. Score	Mean	SD
Male	25	13	23	18.12	2.833
Female	140	8	25	18.86	3.395

Mathematical Uncertainty

Gender	N	Min. Score	Max. Score	Mean	SD
Male	25	5	20	12.08	3.829
Female	140	5	25	12.66	4.127

Shared Control

Gender	N	Min. Score	Max. Score	Mean	SD
Male	25	10	21	15.88	3.586
Female	140	5	25	17.06	4.404

Critical Voice

Gender	N	Min. Score	Max. Score	Mean	SD
Male	25	8	25	20.20	3.266
Female	140	9	25	21.65	3.441

(Continued) Sub-scale Mean Totals for CLES Sub-scale by Gender

Student Negotiation					
Gender	N	Min. Score	Max. Score	Mean	SD
Male	25	10	25	18.84	3.682
Female	140	12	25	21.47	3.237

Sub-scale Mean Totals for the CLES Sub-scales by Education

Personal Relevance					
Education	N	Min. Score	Max. Score	Mean	SD
Bachelor's	52	11	24	18.19	2.884
Master's	82	8	25	18.68	3.496
Specialists	31	13	25	19.87	3.354

Mathematical Uncertainty					
Education	N	Min. Score	Max. Score	Mean	SD
Bachelor's	52	5	18	11.67	3.687
Master's	82	5	20	12.50	3.885
Specialists	31	7	25	14.29	4.748

(Continued) Sub-scale Mean Totals for CLES Sub-scale by Education

Shared Control					
Education	N	Min. Score	Max. Score	Mean	SD
Bachelor’s	52	5	25	16.58	4.272
Master’s	82	7	25	16.50	4.149
Specialists	31	9	25	18.42	4.544

Critical Voice					
Education	N	Min. Score	Max. Score	Mean	SD
Bachelor’s	52	8	25	20.67	3.535
Master’s	82	9	25	21.35	3.543
Specialists	31	17	25	22.90	2.548

Student Negotiation					
Education	N	Min. Score	Max. Score	Mean	SD
Bachelor’s	52	13	25	20.52	3.878
Master’s	82	10	25	20.93	3.216
Specialists	31	16	25	22.39	2.906

ANOVA Results for CLES Sub-scales by Gender

Personal Relevance

Gender	Sum of Squares	df	Mean Square	F	Sig. (p)
Between Groups	11.751	1	11.751	1.067	.303
Within Groups	1795.061	163	11.013		
Total	1806.812	164			

Mathematical Uncertainty

Gender	Sum of Squares	df	Mean Square	F	Sig. (p)
Between Groups	7.242	1	7.242	.434	.511
Within Groups	2719.061	163	16.681		
Total	2726.303	164			

Critical Voice

Gender	Sum of Squares	df	Mean Square	F	Sig. (p)
Between Groups	44.598	1	44.598	3.822	.052
Within Groups	1901.850	163	11.668		
Total	1946.448	164			

(Continued) ANOVA Results for CLES Sub-scales by Gender

Share Control

Gender	Sum of Squares	df	Mean Square	F	Sig. (p)
Between Groups	29.751	1	29.751	1.614	.206
Within Groups	3005.061	163	18.436		
Total	3034.812	164			

Student Negotiation

Gender	Sum of Squares	df	Mean Square	F	Sig. (p)
Between Groups	146.882	1	146.882	13.433	.000*
Within Groups	1782.246	163	10.934		
Total	1929.127	164			

* $p<0.05$

ANOVA Results for CLES Sub-scales by Education

Personal Relevance

Education	Sum of Squares	df	Mean Square	F	Sig. (p)
Between Groups	55.495	2	27.748	2.567	.080
Within Groups	1751.317	162	10.811		
Total	1806.812	164			

(Continued) ANOVA Results for CLES Sub-scales by Education

Mathematical Uncertainty					
Education	Sum of Squares	df	Mean Square	F	Sig. (p)
Between Groups	133.974	2	66.987	4.186	.017*
Within Groups	2592.329	162	16.002		
Total	2726.303	164			

Critical Voice					
Education	Sum of Squares	df	Mean Square	F	Sig. (p)
Between Groups	97.553	2	48.776	4.274	.016*
Within Groups	1848.896	162	11.413		
Total	1946.448	164			

Shared Control					
Education	Sum of Squares	df	Mean Square	F	Sig. (p)
Between Groups	90.071	2	45.036	2.478	.087
Within Groups	2944.741	162	18.177		
Total	3034.812	164			

* $p<0.05$

(Continued) ANOVA Results for CLES Sub-scales by Education

Student Negotiation

Education	Sum of Squares	df	Mean Square	F	Sig. (p)
Between Groups	71.231	2	35.615	3.105	0.470
Within Groups	1857.897	162	11.468		
Total	1929.127	164			

* p<0.05

APPENDIX M

TEACHER BELIEFS SURVEY BY SUB-SCALE STATEMENTS

Problem-solving View of Mathematics Results

Item	Strongly Agree/ Agree	ND	Disagree/ Strongly Disagree	M	SD
1. A vital task for the teacher is motivating children to solve their own mathematical problems.	98.8%	1.2%	0.0%	4.67	.496
3. Ignoring the mathematical ideas that children generate themselves can seriously limit their learning.	89.1%	5.5%	5.4%	4.26	.818
4. Children always benefit by discussing their solutions to mathematical problems with each other.	89.7%	6.7%	3.6%	4.29	.749
5. It is important for children to be given opportunities to reflect on and evaluate their learning.	98.2%	1.8%	0.0%	4.60	.527
6. Allowing a child to struggle with a mathematical problem, even a little tension, can be necessary for learning to occur.	76.9%	16.4%	6.7%	4.03	.913
8. Mathematics is a beautiful, creative, and useful human endeavor that is both a way of knowing and a way of thinking.	81.8%	13.3%	4.8%	4.11	.812

9. Effective mathematics teachers enjoy learning and doing mathematics themselves.	86.7%	4.8%	8.5%	4.25	.935
10. Providing children with interesting problems to investigate in small groups is an effective way to teach mathematics.	93.3%	6.1%	0.6%	4.41	.634
11. Knowing how to solve a mathematics problem is as important as getting the correct solution.	93.3%	3.0%	3.6%	4.59	.723
12. Teachers of mathematics should be fascinated with how children think and intrigued by alternative ideas.	89.7%	8.5%	1.8%	4.35	.713
13. Persistent questioning has a significant effect on children's mathematical learning.	88.5%	9.1%	2.4%	4.35	.746
17. Justifying the mathematical statements that a person makes is an extremely important part of mathematics.	80.0%	16.4%	3.6%	3.96	.735
20. As a result of my experience in mathematics classes, I have developed an attitude of inquiry.	77.5%	16.4%	6.1%	3.86	.732

23. Teachers can create, for all children, a non-threatening environment for learning mathematics.	97.6%	1.8%	0.6%	4.64	.553

Instrumentalists View of Mathematics Results

Item	Strongly Agree/ Agree	ND	Disagree/ Strongly Disagree	M	SD
2. Mathematics is computation.	54.6%	16.4%	29.1%	3.30	1.02
7. It is important for teachers to understand the structured way in which mathematics concepts and skills relate to each other.	93.4%	6.1%	0.6%	4.48	.640
14. If a child's explanation of a mathematical solution doesn't make sense to the teacher it is best to ignore it.	0.6%	3.6%	95.8%	1.67	.608
15. Telling the children the answer is an efficient way of facilitating their mathematics learning.	7.3%	17.0%	75.8%	1.96	.923
16. It is important that mathematics content be presented to children in the correct sequence.	76.4%	16.4%	7.4%	3.99	.890

18. It is important to cover all the topics in the mathematics curriculum in the textbook sequence.	7.9%	8.5%	83.7%	1.98	.880
19. I would feel uncomfortable if a child suggested a solution to a mathematical problem that I hadn't thought of previously.	9.1%	4.2%	86.7%	1.81	1.07
21. There is an established amount of mathematical content that should be covered at each grade level.	31.5% 54.5%	9.7%	3.6% 0.6%	4.13	.774
22. Mathematical material is best presented in an expository style: demonstrating, explaining, and describing concepts and skills.	86.0%	26.7%	20.6%	3.47	1.00
24. It is not necessary for teachers to understand the source of children's errors; follow-up instruction will correct their difficulties.	13.4%	4.8%	81.8%	2.00	1.13
25. Listening carefully to the teacher explaining a mathematics lesson is the most effective way to learn mathematics.	17.0%	6.1%	77.0%	2.23	.985

26. It is the teacher's responsibility to provide children with clear and concise solution methods for mathematical problems.	57.6%	19.4%	23.0%	3.52	1.04

APPENDIX N

CONSTRUCTIVIST LEARNING ENVIRONMENT SURVEY
BY SUB-SCALE STATEMENTS

Item	Strongly Agree/ Agree	Not Decided	Disagree/ Strongly Disagree	M	SD
Personal Relevance					
1. Students learn about the world outside of school.	73.3%	21.8%	4.8%	3.9	.831
2. Students' new learning starts with problems about the world outside of school.	37.0%	53.9%	9.1%	3.33	.768
3. Students learn how mathematics can be part of their out-of-school life.	78.1%	20.6%	1.2%	4.10	.783
4. Students get a better understanding of the world outside of school.	55.1%	36.4%	8.5%	3.59	.883
5. Students learn interesting things about the world outside of school.	64.2%	30.3%	5.5%	3.83	.860
Mathematical Uncertainty	SA/A	ND	D/SD	M	SD
6. Students learn that mathematics has changed over time.	34.6%	29.1%	36.4%	2.99	1.115
7. Students learn that mathematics is influenced by people's values and opinions.	15.7%	28.5%	55.8%	2.45	.990

8. Students learn about the different mathematics used by people in other cultures.	7.3%	25.5%	67.3%	2.13	.934
9. Students learn that modern mathematics is different from the mathematics of long ago.	17.6%	32.7%	49.7%	2.54	1.015
10. Students learn that mathematics is about <u>inventing</u> rules.	21.2%	25.5%	53.3%	2.47	1.134
Critical Voice	SA/A	ND	D/SD	M	SD
11. It's OK for students to ask me "why do I have to learn this?"	85.9%	12.1%	1.8%	4.38	.792
12. It's OK for students to question the way I'm teaching.	72.7%	20.6%	6.7%	4.08	.981
13. It's OK for students to complain about activities that are confusing.	78.2%	14.5%	7.2%	4.09	1.017
14. It's OK for students to complain about anything that prevents them from learning.	82.4%	10.3%	7.2%	4.34	1.027
15. It's OK for students to express their opinions.	93.3%	5.5%	1.2%	4.54	.658

Shared Control	SA/A	ND	D/SD	M	SD
16. Students help me to plan what they're going to learn.	27.8%	26.7%	45.5%	2.85	1.196
17. Students help me to decide how well they are learning.	78.8%	15.8%	5.4%	4.04	.872
18. Students help me to decide which activities are best for them.	50.3%	29.1%	20.6%	3.45	1.107
19. Students help me to decide how much time they spend on activities.	47.3%	31.5%	21.3%	3.39	1.125
20. Students help me to decide which activities they do.	37.0%	35.8%	27.3%	3.15	1.083
Student Negotiation	SA/A	ND	D/SD	M	SD
21. Students get the chance to talk to other students.	89.7%	8.5%	1.8%	4.40	.722
22. Students talk with other students about how to solve problems.	89.7%	9.1%	1.2%	4.32	.688
23. Students explain their ideas to other students.	87.9%	10.9%	1.2%	4.29	.707

24. Students ask other students to explain their ideas.	74.5%	21.2%	4.2%	4.02	.862
25. Students ask each other to explain their ideas.	75.1%	20.6%	4.2%	4.04	.865