KINDERGARTEN STUDENTS' EXPLORATORY MATH TALK WITHIN A COLLABORATIVE DISCOURSE COMMUNITY

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Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
DOCTOR OF EDUCATION
May, 2009

KINDERGARTEN STUDENTS' EXPLORATORY

MATH TALK WITHIN A COLLABORATIVE

DISCOURSE COMMUNITY

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ACKNOWLEDGMENTS

> Rather, I am proposing that teaching, understood as engaging learners in phenomena and working to understand the sense they are making, might be the sine qua non of such research (Duckworth, 1996, p. 168).

The acknowledgments page is generally where authors identify those that have helped in the research and writing process. However, I must begin by honoring the many Kindergarten students I have taught over the years that fueled my passion to learn all I could about teaching. These five- and six-year-olds taught me that my classroom can be a special place: one filled with joy, puzzlement, and a love of learning expressed by the students and the teacher. Thank you for those lessons.

My learning journey did not stop in the Kindergarten classroom. It has been my professors at Oklahoma State University, who, through their words of inspiration and demonstration of true teaching, strengthened my perseverance to continue my quest. To Dr. Kathryn Castle, with her calming words and manner, who reminded me to always listen to the children. To Dr. Pamela Brown, who helped me see that teachers can be the ones conducting the research, 'interrupting' traditional ways of knowing (Cochran-Smith & Lytle, 1993). I would like to extend a special 'thank you' to each of you for your guidance. In addition, I offer sincere appreciation to my committee members, Dr. Mona Lane and Dr. Margaret Scott, for their invaluable insights and belief in the teacher research process.

As this process has been a lesson in shared sacrifice, I would also like to honor my family. My husband, Bill, sparked my initial inquiry into this journey with his question, “Why don’t you go back to school?” Thank you for your faith in me, even when the path seemed too difficult. In addition, to my son, Colt, who inspired me to watch, observe, and listen instead of always telling. And for my daughter, Valentina, who was adopted during this process. My family is my life’s most meaningful work.

Other family members were also a huge support. My sister and “brother”, Cindy and Vince, who made me laugh with anecdotes of how I became the ‘nutty professor’ typing away in the basement. My sister-in-law, Debbie, who is more like a sister to me, gave countless hours watching my children so I could work. I truly appreciate all your love and support.

And to my life’s greatest cheerleaders, my parents, Dale and Pauline Brees, who always believed in me. They lit my desire to learn. Not through textbooks and acquiring others’ ideas, but through my own imagination. I lost them both during my graduate work but I still feel their love for me, lighting my way.

And finally and most importantly, I wish to acknowledge my eternal Father, who has led me on a journey that He has an ultimate purpose for.

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CHAPTER I

INTRODUCTION

Reform in mathematics education remains under debate (Cavanagh, 2006; Fosnot, 2005; Klein, 2007; Van de Walle, 1999). Math wars over the best way to reach mathematical proficiency continue between traditionalists emphasizing basic skill acquisition and constructivists who argue for inquiry and problem-solving. In what was titled the 'Common Ground initiative', proponents from each side met to engage in dialogue about mathematics (Mervis, 2006). While some commonalities were identified, what is seemingly lost in the discussion is the child's voice. What do young children tell us they need to develop mathematically?

For years, educators have been taught to look to the child for the best way to teach (Bredekamp, 2004). However, this voice of reason is increasingly lost in the midst of the accountability movement, which some researchers say forces educators to "treat all students the same, in a sink-or-swim design" (Daro, 2006, p. 4). As standards make their way into early childhood programs, it is imperative that educators reexamine key research on how children learn mathematics (Bredekamp, 2004). Central to this is an understanding of what young children bring to the learning process and how theoretical perspectives can illuminate children's mathematical thinking.

BACKGROUND

Young children are capable learners (Bredekamp & Copple, 1997). While variations in socioeconomic backgrounds, experiences, and cultural differences may play a role in the types of learning they have developed, children are actively engaged in constructing knowledge about their world from birth. In particular, children begin schooling with varying amounts of early mathematical knowledge, much of which was acquired without direct instruction (National Association for the Education of Young Children [NAEYC]/National Council of Teachers of Mathematics [NCTM], 2003). From infancy, young children have developed mathematical understanding through acts of experimentation, puzzlement, and meaningful problem-solving. However, this learning has not occurred in a vacuum (Bredekamp & Copple, 1997). Rather, developmental domains are interrelated. Physical, linguistic, social-emotional, and cognitive growth are closely related. As children progress in one area, the other areas can aid in the development. Recent brain research supports this understanding. "The brain actually functions as a whole in an interactive and integrated manner" (Bergen, 2004, p. 1). Educators are charged with making connections across domains, enabling students to develop optimal growth in all areas.

Researchers are becoming increasingly interested in understanding how children's thinking is shaped by other domains, including language and social experiences (Barnes, 1992; Cazden, 2001; Cobb, 2005; Gallas, 1994, 1995; Lindfords, 1999; Mercer & Sams, 2006; Mercer & Wegerif, 1999; Paley, 1981; Sarama & Clements, 2006a; Wells, 1986; Whitin & Whitin, 2003). Closely related to this perspective are constructivist researchers and theorists who recognize that children do not construct understanding of a concept in isolation but through active engagement with the environment (Fosnot, 2005; von Glasersfeld, 2005). Students need to identify their own questions, generate and test their own theories, and discuss their findings in a community of discourse (Fosnot & Perry, 2005). Such a learning environment promotes knowledge construction as "dialogue within a community engenders further thinking" (p. 34).

The importance of dialogue to cognitive development has been validated by other researchers who found that talk is a primary way that learners explore the relationships between prior knowledge and new learning (Barnes, 1992, 2008; Cazden, 2001; Hyun & Davis, 2005; Lindfors, 1999; Wegeriff, 2005; Wegeriff, Littleton, Dawes, Mercer & Rowe, 2004). Some researchers conclude that talking and learning develop concurrently and suggest that from birth, children attempt to engage others in their sense-making of the world (Lindfors, 1999). The link between talking and learning can continue into the classroom as teachers and students work together not only to communicate but to advance their own understanding (Barnes, 1992).

However, the typical classroom dialogue does not facilitate knowledge construction (Barnes, 1992; Wells, 1986). Barnes proposes that classroom talk is typically teacher-directed with a predetermined answer. Rarely do students pose their own questions. The teacher continues to use "her voice to control and shape the thoughts and attention of the class" (p. 12). He terms this type of talk as presentational. Barnes suggests educators should promote talk that is exploratory. In exploratory talk, children talk their way into ideas as they ." . . make connections, re-arrange, reconceptualize, and internalize the new experiences, ideas, and ways of knowing" (p. 6) with one another.

PROBLEM STATEMENT

As a Kindergarten teacher, I find that young children enter my classroom with an informal understanding of mathematics, much of which has been constructed as students problem-solve and interact with their environment. Educators need to build on and extend these early mathematical beginnings (NCTM, 2000). However, it can be difficult to fully understand a child's conceptual knowledge. I wanted to gain access to my students' thinking as well as identify how to extend their understanding. Current methods of teaching and assessment seemed to limit my awareness of what children knew by focusing on the more observable indicators of learning, such as oral counting and number and shape recognition. However, these are examples of 'surface knowledge' (Kamii, 1982, p. 26) and do not accurately reveal what a child comprehends. As I looked to existing theory for answers, I found that current math reform emphasizes the benefits of fostering talk in the classroom (NCTM, 2000). Through talk, thinking becomes visible both to the learner and the teacher. However, not all talk is created equal (Barnes, 1992). If the aim of classroom dialogue is to provide opportunities for knowledge construction, it is imperative that educators facilitate the kind of talk that builds learning—what Barnes (1992) terms 'exploratory talk'.

PURPOSE OF STUDY

The purpose of this study was to examine what is revealed in Kindergarten students' exploratory math talk and how it could be used to advance understanding of children's mathematical knowledge. In addition, classroom discourse was examined to provide an understanding of the social context affecting the research. I used a teacher research design to gather conversations as students worked together in large- and small-groups to solve mathematical problems. An in-depth analysis of classroom discourse was conducted utilizing a conceptual framework. Categories were open-ended to allow themes or patterns to emerge from the data (Lankshear & Knobel, 2004).

Through this research study, I set out to acquire evidence of children's mathematical talk that corresponded with their internal understanding of mathematics. I hoped to reveal a glimpse into their mathematical minds that the more standard assessment practices do not reveal. In addition, as I analyzed the classroom norms and teacher support evident in the discourse, I wanted to find examples of collaborative inquiry as students worked beyond their present understanding.

THEORETICAL FRAMEWORK

Research into young children's mathematical conversations was based on Piaget's constructivist theory. According to this theory, young children construct their mathematical knowledge internally as they interact with the physical and social environment (DeVries, 1997; Kamii, 2000a). Understanding is viewed as a process in which children progress from a lesser to a more advanced level of knowledge. Learners are viewed as active participants in the construction of their own knowledge as they engage with the world they are interpreting (Crotty, 2004). Meaning is neither objective nor subjective; rather, it is dependent upon the interaction between the object and the subject.

While some constructivists debate whether individual processes are more or less important than social effects, Fosnot and Perry (2005) suggest it is more crucial to understand the interplay between individual and social constructions of learning. They assert that the individual constructs the social world which in turn interacts with the individual. von Glasersfeld (2005) maintains that all learning is individually constructed. Shared meanings are not possible as each learner constructs reality in unique ways. He cautions against terms such as shared knowledge, recommending the term "taken-as-shared" which Cobb (2005) defined as group meanings that are, in actuality, individual constructs of the social phenomenon. "In an interaction, each is constructing the meaning of the other's actions, sometimes misinterpreting and reinterpreting. What is individually constructed thus incorporates constructions of the other's constructions" (DeVries, 2000, p. 209)

Cobb, Wood, and Yackel (1993) find that "mathematics is a social activity . . . as well as an individual constructive activity" (p. 92). Social interaction can act as a catalyst for individual cognitive development. What was crucial for this research is that all participants were considered to be constructing their own knowledge and reflecting on and discussing their present level of understanding with one another in a classroom discourse community.

Chaille and Britain (1997) contend that this process of knowledge construction can be compared to theory building. When an environment is provided that allows for "self-direction, experimentation, problem-solving, and social interaction" (p. 12), students are able to form connections with prior knowledge—in essence, build theories about their world. These theories are continually evolving as students are engaged in experimentation, error, and conflict. This constructivist *lens* defined how the learning environment and the learner were viewed throughout the study.

RESEARCH QUESTIONS

The primary research question was what is revealed in Kindergarten students' exploratory mathematical conversations? Specifically, in examining classroom discourse, the following questions were addressed:

- What mathematical concepts are present in Kindergarten students' exploratory talk?
- What does exploratory math talk sound like in Kindergarten students?
- When do students engage in exploratory talk?
- In what ways are students supported in their math talk?
- How are social norms reflected in math conversations?

SIGNIFICANCE OF STUDY

Education reform calls for constructivist teaching in mathematics (Schifter, 2005). However, researchers acknowledge that it can be difficult to put in place a learning theory that is not a teaching theory (Fosnot & Perry, 2005). In particular, it is important to identify what such an environment looks like for young children. In the joint position statement on early childhood mathematics, NAEYC and NCTM state that "since the 1970's a series of assessments of U.S. students' performance has revealed an overall level of mathematical proficiency well below what is desired and needed" (2003, p. 1). They call for greater attention to be given to early mathematical experiences. Furthermore, they suggest that while much has been gained in understanding what mathematical concepts young children are able to acquire and the methods for teaching these, the vast majority of early childhood programs have a "considerable distance to go to achieve high-quality mathematics education" (p. 2). Reasons behind this discrepancy may include lack of professional knowledge on the part of educators, high levels of math anxiety in society, and an emphasis on more traditional types of mathematics instruction that focus on skills and memorization (Battista, 1999; Bredekamp, 2004). Constructivism, though controversial, remains the best explanation of how children learn based on current cognitive and neurological findings (Fosnot, 2005). Thus, it was necessary to foster a constructivist classroom environment for mathematical development.

LIMITATIONS

While this research project provides information about a select group of young children's mathematical conversations, it is limited in generalizing to other settings. Rather, it is a glimpse into the lives of my Kindergarten students as they explored, solved problems, and discussed their findings *mathematically* in a discourse community. The descriptive nature of the project may allow readers to evaluate the application of the research to their own settings. In addition, as with any qualitative research, the results are limited by the integrity of the investigator who served as the primary instrument for data collection and analysis (Merriam, 1998). With the dual role of teacher/researcher, I acknowledge the unequal relationship between myself and my students. As an ethical researcher, this knowledge came with the responsibility of avoiding any unknown sources of coercion which would have decreased the validity of the study.

MEANING OF TERMS

The following terminology will be utilized throughout the research study to promote clarity and understanding for the reader:

Big Idea: Clements (2004) defines the big ideas of mathematics as "those that are mathematically central and coherent, consistent with children's thinking, and generative of future learning" (p. 13). He suggests that research and theory can recommend what ideas are "challenging but accessible" (p. 13) to young children. Fosnot and Dolk (2001) suggest that big ideas are often linked to shifts in children's reasoning abilities. “These ideas are big because they are critical to mathematics and because they are big leaps in the development of children’s reasoning” (p. 11).

Centration: Piaget (1965) found that young children typically focus on one aspect of a phenomena (centering) such as height or width while disregarding other factors. This is called centration. As children develop cognitively, they move from centration to a more objective view of the world called decentration or decentering.

Collaborative Inquiry: Inquiry means to seek information through questioning (Lindfors, 1999). As an instructional practice, inquiry is based around questions and invites students to work together to solve problems rather than receiving instructions from the teacher. When combined with the word ‘collaborative’, the definition takes on a new meaning to include “a joint production of ideas, where students offer their thoughts, attend and respond to each other’s ideas” (Staples, 2007, p. 162) and generate taken-as-shared meanings or understandings through their combined efforts.

Constructivism: Constructivism is a cognitive learning theory in which learners are viewed as active participants in the construction of their own knowledge as they engage with the world they are interpreting (Fosnot & Perry, 2005). As learners adapt to their environment, they engage in a process of assimilation and accommodation. “Assimilation (to make similar) is activity, the organization of experience” (p. 16). The learner attempts to incorporate new experiences into existing internal schema or relationships. When new experiences do not fit into existing schema, the learner accommodates or modifies the existing mental structures to fit the new experience.

Classroom Discourse: Classroom discourse is the communication system that transpires in the classroom setting (Cazden, 2001). It is the language that students and teachers utilize to communicate with one another. Mercer (1995) terms the type of classroom talk that focuses on teaching and learning as “educational discourse” (p. 80). He notes that traditionally, discourse has followed an Initiation-Response-Feedback exchange where the teacher asks a question, students respond, and the teacher provides feedback.

Conservation: Conservation is a state of understanding in which the learner logically determines that a certain quantity will remain the same despite adjustment of its spatial arrangement or appearance (Kamii, 2000a). Piaget found that children conserve or do not conserve based on their own level of reasoning.

Disequilibrium: Piaget defined this term to mean a state of puzzlement when new information or situations do not fit into one’s existing understanding (Fosnot & Perry, 2005). The learner attempts to reach a state of equilibrium or new understanding called “equilibration” (DeVries, 2005). Fosnot and Perry caution that the term has been misinterpreted and is not a “sequential process of assimilation, then conflict, then accommodation” (p. 18). Rather it is a nonlinear process of adaptation, growth and change.

Egocentricity: Egocentricity can be viewed as “being able to think only from one point of view, usually one’s own” (Kamii, 2000a, p. 40). Piaget (1997) found through his research that young children do not have the mental ability to understand that other people may have different opinions and beliefs. However, when children express points of view with each other, they are forced to decenter and appreciate others’ perspectives.

Exploratory Talk: Douglas Barnes (1992) is perhaps best known for his research on exploratory talk. "I call this groping towards a meaning 'exploratory talk'. It is usually marked by frequent hesitations, rephrasing, false starts, and changes of direction" (p. 28). Barnes also compared exploratory talk to the first draft stage of writing. In addition, Cazden (2001) identifies exploratory talk as "speaking without the answers fully intact" (p. 170). Exploratory talk occurs when students use language to explore their thinking.

Logico-Mathematical Knowledge: Piaget identified three types of knowledge, including social knowledge which includes the language and conventions created by society; physical knowledge that involves learning about objects in their external reality; and logico-mathematical knowledge which consists of mental relationships that are created internally by each individual (Kamii, 2000a).

Math Talk: Classroom talk that supports mathematical learning which may include talking about mathematics, explaining answers, or describing strategies used to solve problems (NCTM, 2000).

Mathematical Discourse Community: A mathematical discourse community is a social environment that encourages classroom dialogue that supports mathematical learning (Chapin, O'Connor, & Anderson, 2003). Establishing a safe, nurturing environment where students feel comfortable sharing their thinking requires planning, such as setting ground rules for talk.

Presentational Talk: Barnes (1992, 2008) identified classroom talk that emphasizes rote learning with a predetermined answer as presentational talk. He notes that presentational talk is typically utilized for testing students on information already taught. During presentational talk, the speaker is focused on the needs of the audience as opposed to exploratory talk where students are focused on sorting their own thoughts.

Problem Solving: NCTM (2003) identifies learning to solve problems as the major goal of school mathematics. They recommend that students be given opportunities to apply the mathematical concepts learned to solve thought-provoking problems.

Qualitative Research: Qualitative research is a field of inquiry that focuses on "a deep understanding of a social setting" (Bloomberg & Volpe, 2008, p. 7). Qualitative research differs from quantitative research in many ways, including the role of the researcher who is the primary means for data collection and analysis. In addition, qualitative research is usually done in a natural setting, utilizes an inductive research method, and is richly descriptive (Merriam, 1998).

Reasoning: Reasoning can be defined as making sense of something and is essential to mathematical understanding (NCTM, 2000). Yackel and Hanna (2003) differentiate between mathematics as reasoning and mathematics as a series of rules and procedures. While they note that students may gain an understanding through set procedures, they do not develop an understanding of the underlying relationships of mathematics. Opportunities to explain, challenge, and defend promote the development of reasoning.

Representation: NCTM (2000) defines representation as ways in which children represent their thinking. These can include picture drawing, use of manipulatives, or writing. Representations can also be used to communicate thinking and to model mathematical concepts. Piaget (Kamii, 2000a) distinguished between signs and symbols which many view as representations. Signs are considered social knowledge and can include number writing and therefore, cannot be invented by the child. Symbols, however, represent the child's thinking and are invented by the child.

Scaffold: Mercer (1995) identifies scaffolding as talk that guides and supports the learner which is increased or withdrawn based on developing competence. However, DeVries (2000) cautions that terms such as "guide and support" have been left open to interpretation, resulting at times in a more behaviorist application. The concept of scaffolding through talk can describe how a teacher or students can be actively engaged in another student's learning activity (Mercer, 1995). While the learner is at the forefront of the learning activity, he or she is able to progress further in understanding through others' interactions.

Social Norms: Social norms are rules that a group uses to define appropriate and inappropriate behavior that transpire in the classroom (Yackel & Cobb, 1996). In math, social norms "regulate the activity of doing and talking about mathematics" (Cobb, Wood, & Yackel, 1993, p. 105).

Sociocognitive Conflict: Sociocognitive conflict can be defined as an intellectual disagreement between learners (Kamii, 2000a). Piaget found that sociocognitive conflict is essential for a learner's progression through various cognitive stages. Doise, Mugny, and Perret-Clermont (1976) conclude that "conflicts of cognitive centration, embedded in a social situation, are a powerful factor of cognitive development" (p. 245).

Sociomoral Classroom: A sociomoral classroom supports and promotes children's social, moral, and cognitive development (DeVries & Zan, 1994). A feeling of community is emphasized as students make decisions about classroom life, discuss social and moral problems, and engage in negotiations with peers and teachers (DeVries, 2000).

Speech Disfluencies: Speech disfluencies can include irregularities that occur within the flow of more fluent speech (Cazden, 2001, Eklund, 2004). These can include fillers such as um or er, repeated phrases, or other disfluencies. Cazden suggests when students try to form ideas while speaking, the result may be difficult to understand.

Teacher Research: Cochran-Smith and Lytle (1993) define teacher research as a "systematic and intentional inquiry carried out by teachers" (p. 7). Lankshear and Knobel (2004) redefine teacher researchers as "classroom practitioners at any level . . . who are involved individually or collaboratively in self-motivated and self-generated systematic and informed inquiry undertaken with a view to enhancing their vocation as professional educators" (p. 9).

CHAPTER SUMMARY

This chapter describes the critical components necessary to complete this study, including the problem, purpose, and research questions which are aligned to promote cohesiveness. In addition, the theoretical framework, significance of the study, and key definitions are also shared. To conduct the investigation, a broad spectrum of theory and research was examined. These perspectives will be explored more closely in Chapter Two, revealing their influence on the current research study. The research methodology is explained in Chapter Three, including a rationale for a qualitative teacher research stance and identification of the participants, setting, data collection methods, and analysis procedures. The research findings resulting from the data collection and analysis are shared in Chapter Four. Chapter Five presents the conclusions and recommendations for practice and future research along with the researcher's personal reflections.

CHAPTER II

REVIEW OF LITERATURE

INTRODUCTION

The purpose of this study was to identify what was revealed in Kindergarten students' exploratory math talk. Specifically, the researcher sought to understand what mathematical understandings were present in their talk and to examine the social context of the classroom affecting the study. To complete this study, it was necessary to conduct a critical review of current literature. The review was ongoing throughout the data collection, analysis, and synthesis stages of the study. Both current theory and research were examined as well as significant studies that had been conducted in the past.

During a review of literature on math talk and mathematics, various themes emerged and were explored. These included (a) the history of mathematics education in the United States; (b) a constructivist approach to mathematics; (c) language and learning; (d) social interactions; (e) exploratory talk; (f) mathematical discourse; and (g) mathematical discourse communities. A literature review of these themes provides an understanding of the history, current research, and areas for future inquiry to promote insight and understanding into the overall topic. However, these understandings must be intertwined with knowledge of the young learner. In recent years, early childhood education has faced an "'accountability shovedown' that threatens the integrity of early childhood professionals and the quality of educational experiences for young children"

(Hatch, 2002, p. 457). A myriad of expectations have been forced on young children, many that do not take into account how they learn. This necessitates a view of the young learner that informs both the literature review as well as the research process. In addition, constructivist theory is reviewed throughout the chapter to provide a context for understanding. Finally, a conceptual framework is revealed, drawing on implications from research along with insights and experiences of the researcher. This process of honing the research question will provide an organizing structure for the remaining research process.

HISTORY OF MATHEMATICS EDUCATION IN THE UNITED STATES

OVERVIEW

Classrooms and talk would seem to go together. As children engage with teachers and classmates, formal and informal discussions arise (Barnes, 1992). However, in a not so distant past, educators believed that a quiet classroom reflected a high level of control and was the epitome of teaching success (Edwards, 1994; Kohn, 2000). Teachers learned to quickly silence their students when a principal walked by. Upon entering such a classroom, visitors would find students quietly engaged in study, heads bowed as they completed independent seat work. When talk occurred, it was largely teacher-directed as students answered predetermined questions, hoping to gain the teacher's approval (Barnes, 1992; Edwards, 1994; Wells, 1986).

Mathematics, in particular, emphasized rote learning with little discussion or dialogue (Battista, 1999). However, a large body of research on how children learn challenged this passive view of the learner and introduced a cognitive learning theory, constructivism (Fosnot, 2005). In constructivism, learners construct knowledge by building it internally rather than acquiring it directly from the environment (Kamii, 2000a). Yet this theory was met with resistance by both educators and theorists, initiating the math wars that are prevalent today (Fosnot, 2005). It is important to examine why constructivism was, and remains, such a radical departure from more traditional math instruction.

FINDINGS

During the early 20th century, learning was defined as a “change in behavior” (Fosnot, 2005, p. 276). Learning tasks were viewed as a series of skills, arranged from simple to complex, that the learner had to master before moving on to another concept. In such an environment, teaching emphasized drill and practice. This learning approach was based on behaviorist theory which “reinforced the commonsense belief that drill and reinforcement enhance the internalization of knowledge” (Kamii, 2000a, p. 16). Behaviorism stems from an empiricist theory of knowledge. Empiricists believe that knowledge exists outside the individual and must be internalized directly from the environment.

In mathematics education in particular, the behaviorist mode of instruction emphasized memorization of facts and algorithms that held little meaning to the students (Battista, 1999). Timed tests, textbooks, and pencil-and-paper computation—these represented mathematical instruction in the traditional domain to several generations of students and would directly influence how mathematics was taught even in the midst of later mathematics reform. Numerous research studies indicated that the traditional method of teaching mathematics was not only ineffective, but also seriously limited the development of students’ problem-solving skills and reasoning abilities (Kilpatrick, 2003). In 1976, the National Science Foundation prepared three studies on mathematical teaching practices (Fey, 1981). James Fey, in his summary of the reports, states "this suggests very common use of an instructional style in which the teacher explanation and questioning is followed by student seatwork on paper and pencil assignments" (p. 6). The emphasis on procedures over understanding impacted student test scores as well. The National Assessment of Education Progress [NAEP] examines students' mathematical learning in the United States (Kenney, 2000). Test results from that time period indicate that students were proficient in computation problems but were typically unable to solve problems that involved reasoning or higher-level thinking (Wearne & Kouba, 2000).

During the late 1980's, a major paradigm shift began in mathematics with the introduction of the Curriculum and Evaluation Standards for School Mathematics, published by NCTM in 1989 (Kilpatrick, 2003). These standards were based on Piaget's constructivist view of learning and directly challenged "the very nature of school mathematics" (Battista, 1999, p. 2) which relied on a behaviorist approach. While Piaget acknowledged that behaviorism is a scientifically-proven theory, he found that it represents only a small part of learning (Kamii, 2000a). Kami notes that "it is likewise still true, from the limited perspective of surface behavior, that drill and reinforcement 'work'" (p. 16). Piaget's constructivism encompasses behaviorism by placing the learner at the very forefront of the learning process.

> Teachers who base their practice on constructivism reject the notions that meaning can be passed on to learners via symbols and transmission, that learners

can incorporate exact copies of teachers' understanding for their own use . . . and that concepts can be taught out of context (Fosnot, 2005, p. ix).

Reform efforts became widespread throughout many American schools as educators attempted to change their teaching in accordance with NCTM's standards of 1989 and the Principles and Standards for School Mathematics [PSSM] released in 2000 (Klein, 2007). The later document introduced prekindergarten standards for the first time, causing states to examine and modify their programs for young children (Clements, 2004). However, reform was met with much opposition from both teachers and parents, many of whom had been raised in the era of traditional mathematics instruction (Battista, 1999; Klein, 2007).

In May of 2000, the Conference on Standards for Prekindergarten and Kindergarten Mathematics Education was held (Clements, 2004). The purpose of the conference was to bring together educational leaders to coordinate standards, curricula, and teaching methods appropriate for mathematical learning in young children. An overall conclusion from the conference was that young children possess an informal understanding of mathematics that is often underestimated. Early childhood classrooms must connect these early understandings to more formal ways of knowing. Young children need opportunities to reinvent and redefine what is first understood intuitively in regards to mathematics. Emphasis should be placed on learning what are termed the "big ideas" (p. 15) of mathematics, which include number and operations, algebra, geometry, data analysis, and measurement. However, Clements acknowledges that "at present, most teachers do not know what to do about mathematics for the young children with whom they work" (p. x).

To assist teachers with implementing mathematics reform, NCTM (2006) published the Curriculum Focal Points which identifies key mathematical topics for each grade. Some critics argued that NCTM, with the release of its focal points, was admitting the weakness of their standards ("Fuzzy Teaching Ideas", 2006). However, NCTM maintained that the focal points were created to correctly implement the standards (Fennell, 2006). In a letter to the editor of the New York Times, Francis Fennell, former president of NCTM, writes:

> What some refer to as basic skills . . . have always been a fundamental core of elementary school mathematics. Always. But we want more. We want children to understand the mathematics they are learning and we want them to be able to solve problems, which is, in the long run, why we do mathematics (p. 1).

In 2008, the U.S. Department of Education released 'The Final Report of the National Mathematics Advisory Panel' (National Mathematics Advisory Panel, 2008). The panel examined what President Bush termed the "best available scientific research" (p. xv) to use for improving school mathematics. The report highlights findings on how to strengthen mathematics education, including the need for a "focused, coherent progression of mathematical learning with an emphasis on proficiency with key topics" (p. xvi). However, the panel has met with controversy. Boaler (2008) writes that only quantitative research with its emphasis on "randomized controlled trials" (p. 3) was accepted, excluding a large body of qualitative research. In addition, other critics have noted that the majority of the panel participants were known as critics of constructivist-based mathematics (Cavanagh, 2006).

Currently, various extremes of the mathematical continuum can be found in our nation's schools (Fosnot, 2005). Some educators advocate the need for basic skill acquisition, adhering to a more traditional form of mathematics instruction. Others follow what they view as constructivist theory. Early childhood classrooms in particular have felt the inconsistency among standards and guidelines (Clements, 2004). While math standards are now more commonly found in early childhood instruction, many of the accompanying curriculum and teaching strategies may be inappropriate for young students. Fosnot (2005) suggests that part of the problem may lie in misinterpretations of constructivism, "often equating it with hands-on learning, discovery, and a host of pedagogical strategies" (p. 277).

> We again run the risk of short-lived reform, or "fuzzy-based" practice unless educators understand the theory, the connections across the disciplines of reforms, and the major restructuring that is needed in schools . . . if we are to take constructivism seriously (p. x).

IMPLICATIONS

Constructivism has been shortchanged in many American classrooms (Fosnot, 2005; Van de Walle, 1999). Public misconceptions, the math wars, misinterpretations--all have played a role in limiting its value to education. Thus, it is important to add to the knowledge base on how mathematics reform can be achieved in the classroom setting. In addition, reform has been particularly inconsistent for the early childhood classroom and should be a topic of further study (Bredekamp, 2004; Clements, 2004).

Kamii (1982, 2000a) and Battista (1999) question the continued illogical practice of teaching mathematics without an underlying understanding of scientific theory.

Mathematics is not memorization. It requires "error, conflict, and contradiction" (Chaille & Britain, 1997, p. 6) to result in meaningful knowledge construction. This knowledge alone should change the focus of the math wars—not by identifying the best method of mathematical instruction but instead by focusing on how children construct mathematical knowledge (Kamii, 2000a).

A CONSTRUCTIVIST APPROACH TO MATHEMATICS

OVERVIEW

> The mathematics classroom was to become a community of inquiry, a problem-posing and problem-solving environment in which developing an approach to thinking about mathematical issues would be valued more highly than memorizing algorithms and using them to get the right answer (Schifter, 2005, p. 85.

A constructivist approach to mathematics teaching requires a change in paradigm (Fosnot & Perry, 2005; Van de Walle, 1999). Educators teach as they were taught, which for many is based on the behaviorist approach to mathematics (Battista, 1999; Duckworth, 1989). Mathematical knowledge, however, is no longer viewed as the acquisition of skills. Rather, it is "first and foremost a form of reasoning" (Battista, 1999, p. 428). Mathematics requires logical thinking—the ability to formulate and test assumptions in an attempt to make sense of the world. Constructivist theory proposes that knowledge is constructed from within through the act of abstraction, not by absorbing information from teachers or textbooks (Battista, 1999). Kamii (2000a) identifies two types of abstraction: 1) empirical abstraction in which the learner focuses on one property of an object, ignoring the other properties; and 2) constructive abstraction, also called reflective abstraction, that involves creating relationships between two or more objects. The similarity or difference between objects is constructed by each learner through reflective abstraction.

Fosnot and Perry (2005) believe that reflective abstraction is vital to the learning process. “As meaning makers, humans seek to organize and generalize across experiences in a representational form” (p. 34). In examining recent neuroscience research, Battista (1999) maintains that abstraction is crucial for the construction of mental ideas that are used to reason about mathematics. However, to truly understand mathematics, reflection over past experiences or actions involving mathematical ideas is necessary. As children communicate their mathematical understanding, they are reflecting on and revising their thoughts (Fosnot & Perry, 2005).

To facilitate children’s thinking, educators must be cognizant not only of what each child brings to the classroom environment but work to foster young children’s innate abilities to solve meaningful problems (Chaille & Britain, 1997; NCTM, 2000). This dynamic, interactive process builds on children’s prior knowledge. Battista (1999) finds that “virtually all students enter school mathematically healthy and enjoying mathematics as they solve problems in ways that make sense to them” (p. 426). As children solve problems, they are applying their understanding of mathematics in meaningful ways. NCTM (2000) states that “the most important connection for early mathematics development is between the intuitive, informal mathematics that students have learned through their own experiences and the mathematics they are learning in school” (p. 132). Educators must provide opportunities for children to make connections that clarify and extend their thinking. Young children need opportunities to experiment and fail; modify and try again. Such an environment invites conflict, error and discovery through peer and teacher interactions (Fosnot & Perry, 2005).

FINDINGS

In examining current research on constructivism and mathematics, several significant studies were identified supporting constructivist teaching. Kamii (1994) found that algorithms can be harmful to students' reasoning abilities. Utilizing a quantitative research method, Kamii studied second graders and their ability to solve an addition problem requiring regrouping. One class was taught using traditional algorithms by the teacher. The second class followed constructivist principles in the classroom, but had been introduced to algorithms at home. The final class, the non-algorithm group, invented their own strategies according to constructivist theory. Kamii found that the non-algorithm group had the highest percentage of correct answers. In addition, many students in the algorithm group gave unreasonable responses. Kamii maintains that algorithms are harmful because "they encourage students to give up their own thinking and they 'unteach' place value" (Kamii, 2000a, p. 83).

In addition, Kamii (2000a) compared two groups of first graders as they solved word and computation problems. One group was referred to as the 'constructivist' group. The majority of these students had been in a constructivist Kindergarten classroom and were currently in a constructivist first grade. The second group, known as the 'textbook' group, had a similar population but were instructed using a textbook series and workbooks. Data were collected using individual interviews with the students. For the first part of the study, students were given word problems to solve. Pencil, paper, and counters were available for use. Students were asked to explain their responses which varied in difficulty and included some multiplication and division problems. For the second part of the study, students were given computation problems to answer within a predetermined time limit.

Kamii's (2000a) findings suggest that the constructivist group was able to reason more logically. Some students were able to do multiplication and division word problems, something typically not introduced in first grade textbooks. In addition, the constructivist group had higher scores on the computation problems. Many of the students from the textbook group answered illogically, indicating that "textbook instruction not only failed to develop children's logico-mathematical knowledge but also began to harm their ability to reason numerically" (p. 228).

However, not all research indicates the superiority of constructivist teaching when compared to traditional instruction. Chung (2004) examined third graders' ability to learn multiplication facts. Four classrooms participated in the quantitative study. Two classrooms received traditional instruction on multiplication; the remaining classrooms were taught using a constructivist approach. Using a pre-test/post-test design, both groups of students showed significant gains in their multiplication skills The researcher found no statistical difference between the two groups based on type of instruction. However, the author acknowledges that the instructor using the constructivist approach expressed difficulty in teaching multiplication through the use of manipulatives and would have benefited from additional training.

IMPLICATIONS

Constance Kamii's research remains highly influential in mathematics reform (NCTM, 2000). Her findings support the use of constructivist theory to teach mathematics. What was interesting to note was the superiority of the constructivist group in computation skills. Many supporters of traditional math instruction emphasize the need for basic skills, erroneously believing these skills are overlooked in constructivist classrooms. However, rather than applying a behaviorist model of memorization, constructivists believe children need opportunities to construct an understanding of such concepts (Fosnot, 2005; Hiebert, 2003).

While there were no statistical differences between the two groups of students in Chung's (2004) findings, her research highlights the difficulty many educators have in applying a theory of learning, not teaching, to the classroom setting (Fosnot, 2005). This indicates that further studies are needed on applying constructivist theory to instruction.

All three of the studies cited utilized quantitative research methods. However, Cochran-Smith and Lytle (1993) question the cause-and-effect type relationships often found in quantitative studies when applied to the classroom setting. Qualitative research can provide a deep understanding of a social setting (Bloomberg & Volpe, 2008). Thus, an area for further study would be to examine mathematical teaching in a constructivist classroom utilizing a qualitative research method. Such a classroom, based on a constructivist approach to mathematics, would include opportunities for students to solve meaningful problems and invite constructive abstraction (Fosnot, 2005). In addition, discourse has been called for in mathematics reform (NCTM, 2000). Attention must be given to examining the connection between language and learning to determine the role talk can play in knowledge construction.

LANGUAGE AND LEARNING

<u>OVERVIEW</u>

> Really to understand where a child is and, hence, how we can most helpfully contribute to his or her further learning, it is necessary to listen to what he or she has to say—to try to understand the world as he or she sees it (Wells, 1986, p. 118).

The classroom is a social place; filled with individuals actively engaged in learning (Barnes, 1992; DeVries & Zan, 1994; Kamii, 2000a). With such learning comes a steady stream of language. Many researchers have been puzzled by the link between language and thinking (Cazden, 2001; Mercer, 1995; Wells, 1986). Fosnot (2005) writes "What is the interplay between language and thought? Is language just a symbolic representation of previously constructed ideas or does language actually affect thought?" (p. 26).

The role of language in cognitive development is one of the most noted differences between constructivist theorists, Piaget and Vygotsky (DeVries, 2000). Piaget (1926) found that language does not necessarily mirror a child's understanding and that reasoning is reflected in actions, not words. In his early works, Piaget believed that language can be a misleading indicator of what a child knows (Duckworth, 1996). In his later research, he maintained that a large amount of logic is not revealed in speech. Vygotsky (1934/1986), however, disagreed as he believed that language is essential to the development of thought. He found that there is a strong connection between speech and cognitive development. Vygotsky described inner speech as very different from external speech (Berk & Winsler, 1995). External speech turns thoughts into spoken words. Inner speech is the opposite, turning words into thoughts.

Piaget and Vygotsky also differed in their interpretations of children's early speech (Berk & Winsler, 1995). Both theorists discovered that young children typically talk to themselves as they engage in activities. This self talk is commonly known as "private speech" (p. 34). Piaget viewed private speech as egocentric, reflecting a child's inability to take others' perspectives. He believed that private speech would be replaced with more advanced talk as the child's cognitive abilities developed. Vygotsky (1934/1986), however, felt that private speech occurred when children were working on difficult tasks. He believed this type of talk was not used to communicate with others. Rather, it was to enable learners to be self-regulated "as they guide their behavior verbally" (Berk & Winsler, 1995, p. 37). Private speech becomes gradually internalized to become inner thoughts.

Barnes (1992) offers a different view of talk and learning. He maintains that language, while not the same as thought, allows learners to reflect on their thoughts. Barnes contends that this view of talk and learning is not in opposition to Piaget's constructivism. "There is an important difference between arguing that the development of cognition depends on the development of language—an assertion which Piaget has firmly rejected—and arguing that speech enables us to control thought" (p. 101).

The importance of dialogue to cognitive development has been validated by researchers who found that talk is a primary way that learners explore the relationships between prior knowledge and new learning (Barnes, 1992; Cazden, 2001; Fello, Paquette & Jalongo, 2006/2007; Gallas, 1994; Lindfors, 1999). Barnes makes the distinction between school knowledge and action knowledge, maintaining that school knowledge is what is presented to students, typically by teachers. "We partly grasp it, enough to answer the teacher's questions, to do exercises, or to answer examination questions, but it remains someone else's knowledge, not ours" (p. 81). Action knowledge, however, is knowledge that has been internalized by the learner. He maintains that through language, children are able to make learning their own. "They will be both putting old familiar experiences into words in order to see new patterns in it and trying to make sense of new experiences by finding a way of relating it to the old" (p. 83). However, Barnes contends that classrooms typically view talk as a means of communication, failing to recognize its role in learning. "Through language we both *receive* a meaningful world from others; and at the same time *make meanings* by re-interpreting that world to our own ends" (p. 101).

Mercer (1995) agrees that talk can guide a child's knowledge construction as knowledge is both individually and socially constructed. Furthermore, Mercer suggests that a teacher or even another child can enter in to a learner's construction process through talk. Lindfors (1999) likens the act of inquiry to a language act in which the learner engages another's help in going beyond current levels of understanding. This "emergent inquiry" (p. 48) can continue into the classroom setting through communication acts between teachers and students.

FINDINGS

Other researchers have examined the connection between classroom talk and learning (Lindfors, 1999; Gallas, 1994; Fello, Paquette & Jalongo, 2006/2007). Lindfors studied conversations that occurred in Vivian Paley's kindergarten classroom. She cites transcripts that reveal how individuals go beyond their initial understandings and contribute to the thinking of others during classroom discussions. Gallas, using a teacher research design, examined the science talks that occurred in her primary age classroom.

She finds that the children co-construct or build ideas together about science concepts. "I could view how their ideas developed, watch theories being built, and be amazed at the power of a group of children thinking together" (p. 12). She compares this process to that of scientific discovery where scientists engage in discourse, interact with materials, and engage in error and conflict as they build theories.

In addition, Fello, Paquette and Jalongo (2006/2007) studied the use of talking drawings with older elementary students using a qualitative research design. Talking drawings enable students to illustrate their understanding of science topics using artwork to integrate new knowledge with prior knowledge. While drawing, students are engaged in discourse about their illustrations with a partner. The researchers found that students' pre- and post-drawings clearly reflected learning and enabled students to conceptualize abstract ideas as they shared their thinking through talk.

IMPLICATIONS

Language and its role in learning continues to be of interest to researchers. "Questions about the relation of thought and language have fascinated scholars for centuries" (Lindfors, 1999, p. 226). While the importance of language to development is debatable, Barnes (2008) suggests that language allows us to control and reflect on our thoughts. This is necessary for knowledge construction because, as the learner reflects over past experiences and actions, related abstractions are integrated into more complex relationships (Battista, 1999).

In addition, talk is now more commonly found in classrooms due to reform efforts (NCTM, 2000). However, the cognitive benefits that may arise when students engage in discourse is not typically understood (Barnes, 1992). Through this research, the reader may visualize how student talk can be a viable means not only for communication but for cognitive development.

In examining the research on talk and learning, the qualitative, holistic nature of the studies promotes application to my own classroom. In particular, Gallas' (1994) teacher research has been especially inspiring as her question about what children know is similar to my own. All three of the studies demonstrate how learners work together to construct knowledge. However, it is important to emphasize that all learning is individually constructed (von Glaserfeld, 2005). With this in mind, DeVries (2000) suggests that those with Piagetian views need to move "toward greater appreciation of the co-construction of meaning in social interaction" (p. 209). She recommends that further study is needed to understand how individuals constructing knowledge in social settings can support one another. My research study examines Kindergarten students' mathematical conversations as they engage in problem-solving activities. Their constructions of knowledge are their own. However, they are supported in their construction by others, including their peers and teacher. Thus, it is important to examine how social interactions can facilitate learning.

SOCIAL INTERACTIONS

OVERVIEW

Social relationships play an increasingly significant role in children's lives (Bredekamp & Copple, 1997). From infancy, babies show an interest in the faces of other infants. Young children, while not able to play cooperatively, will parallel play alongside their peers. Learning to interact with other children is a crucial goal in many early childhood programs. Peer relationships not only affect a child's cognitive development, but also their social and moral development (DeVries & Zan, 1994). As children interact with children their own age, the relationships formed are characterized by an equality that can never be attained in adult-child relationships.

The centrality of social interactions to development is most commonly attributed to sociocultural constructivism influenced by Vygotsky (DeVries, 2000). However, DeVries notes that this belief misrepresents Piaget's theory. Piaget was both an epistemologist as well as a psychologist. The study of epistemology looks at how knowledge develops (Crotty, 2004). Thus, his emphasis on individual constructs was necessary. As a psychologist, however, Piaget emphasized the central role of social factors in knowledge construction (Devries, 2000). He believed that young children begin by being egocentric in their thinking which limits their ability to construct complex relationships (Kamii, 2000a). However, through social interactions, construction of logic can occur because learners are forced to reorganize their thinking in order to make sense to others.

In recent years, cooperative learning strategies have become more commonplace in education (Mercer, 1995). Kamii (2000a) notes that there are various connotations of the meaning of cooperation which can imply compliance. She challenges the use of the term when applied to mathematics, referring instead to Piaget's definition of the word. Piaget viewed "cooperation" as "co-operation" to mean learners operating together. "Operating together for Piaget meant to work together, by exchanging points of view, and negotiating solutions in case of disagreement" (p. 43). Classrooms that support opportunities for children to engage with their peers in such a manner promote optimal growth in all developmental domains. DeVries and Zan (1994) view this type of environment as a sociomoral atmosphere that "fosters children's intellectual, social, moral, emotional, and personality development" (p. 1). However, it is not just through peer interactions that children's cognitive and moral development occurs. Teachers and students can engage in ways that are mutually respectful. In such a relationship, the teacher promotes opportunities for the children to exercise their own will while understanding that adults and children are not equals.

FINDINGS

Social relationships have been the topic of research in recent years. DeVries and Zan (1994) studied three types of classrooms which they term "the boot camp", "the factory" and "the community" (p. 7). In the boot camp classroom, students must conform to the teacher's rigid expectations and directions. The emphasis is on competition rather than cooperation. Children are rarely given opportunities to interact with each other and when they do, are quickly admonished for talking. In the factory classroom, children are less directed than in the boot camp classroom. However, the teacher has strict control and conformity is emphasized. When peer interactions occur, they are stifled by the controlling nature of the teacher. In the community classroom, however, the teacher and children interact with respect. There is a feeling of togetherness as children and adults engage in shared decision-making.

Using a qualitative research design, the study examined how children negotiate without adult interference. Pairs of children from each classroom were videotaped while playing a game and dividing stickers. Videotapes were then transcribed and analyzed. Results indicate that children from the community classroom interacted more and were better able to take the other's perspective into account. In addition, their negotiations were more skillful and conflicts were resolved more positively. Boot camp students tended to be more aggressive either verbally or physically in resolving conflict. DeVries and Zan (1994) suggest that the teacher's role in promoting a sociomoral classroom involves "defining the possibilities, engaging with children at times as a peer, and facilitating interaction when children's self-regulation fails" (p. 56). Classrooms are set up to foster collaboration throughout the day. Teachers can interact with their students as a peer, such as playing a game or engaging in conversation. In such an environment, opportunities for peer interaction occur naturally.

However, Mercer (1995) cites research on group work among primary aged students that indicates collaborative activity rarely occurs in the classroom. Instead, children are typically working on individual tasks. While conversations might occur, the activities they are completing do not encourage opportunities to collaborate or interact with a peer. He suggests that children be taught to collaborate in ways that do not emphasize competition. Students need to learn how to reason together by analyzing problems, sharing ideas, and reaching joint decisions that may involve disagreement or conflict.

Piaget also valued the role of conflict in peer relationships (Kamii, 2000a). He believed that conflict is crucial to understanding the learner's progression through different cognitive development stages. Piaget studied conflict within individuals as well as conflict in social situations (DeVries, 2005). He found that internal conflict is vital to the equilibration process. Piaget defined this term to mean a state of puzzlement when new information does not fit into one's existing understanding (Fosnot & Perry, 2005). The learner attempts to reach a state of equilibrium or new understanding called equilibration (DeVries, 2005). When applied to social settings, “the subject comes to reorganize and restructure cognitions as a result of confrontation with opposing points of view” (Bell, Grossen, & Perret-Clermont, 1985, p. 42).

While Piaget emphasized the significance of conflict in social interaction, he did not carry out research to prove his theory (Kamii, 2000a). Others have further researched Piaget’s findings, adding to the knowledge base of what is termed sociocognitive conflict (Kamii, 2000a). However, Bell et al. (1985) caution that not all peer relationships facilitate sociocognitive conflict as viewpoints must be opposed and in need of reorganization. In addition, learners must have what they term “certain cognitive prerequisities” (p. 45) or prior knowledge in order to understand the task and play an active role in the discussion.

In examining research on sociocognitive conflict, two important studies came to light that demonstrate the role of conflict in increasing children’s levels of reasoning (Doise & Mugny, 1984; Perret-Clermont, 1980). Doise and Mugny studied sociocognitive conflict using a conservation of length task with a pre-test/post-test design. In individual interviews, children were shown two identical sticks placed in a horizontal line, one above the other, and asked if the sticks were the same. After responding, one of the sticks was adjusted spatially, pushing it farther to the right. Students who identified that the sticks were the same size regardless of their spatial arrangement were called conservers. Nonconservers, however, believed that the stick that was adjusted was the longest. In a separate session with nonconservers, an adult stooge was used who gave an answer that contradicted the child’s response when retested on conservation tasks. Nonconserving students that argued with the stooge showed considerable progress on the post-test as compared to those students who did not disagree. Kamii (2000a) suggests that this study is significant because the arguments of both participants (the nonconserver and the adult stooge) were incorrect. The correct answer had to be constructed out of the two lower relationships through sociocognitive conflict.

In addition, Perret-Clermont (1980) studied sociocognitive conflict in Kindergarten and first graders using a quantitative, pre-test/post-test design. Students were pretested using a conservation of liquid task to determine if they were conservers, nonconservers, or in between. Students were then randomly assigned to control and experimental groups. The control group received no intervention. The experimental group, however, was divided into groups of threes. Two members of the trios were conservers; the remaining child was either a nonconserver or in between. The groups were put into situations that encouraged disagreements and were retested using two post-tests. The results indicate that a large percentage of nonconservers showed substantial growth as compared to the control group. The experimental group was retested at a later date. Results indicate that students maintained their understanding.

IMPLICATIONS

Young children are social beings. Rather than limiting this natural tendency, the classroom should support social interactions that are ripe with negotiation, conflict, and perspective-taking (Devries, 2005; DeVries & Zan, 1994). However, not all interactions lead to knowledge construction (Kamii, 2000a; Mercer, 1995). It is important to identify the types of conditions that promote meaningful interactions in the classroom. These include 1) a sociomoral atmosphere where students and teacher engage with one another respectfully (Devries & Zan, 1994); 2) opportunities for children to exchange points of view with their peers (Kamii, 2000a); 3) activities or tasks that engage students in collaboration, not simply conversations while they work independently (Mercer, 1995); 4) children being taught to reason together; 5) disagreements that are viewed as viable means of knowledge construction (Bell et al., 1985); and 6) the teacher's role as a peer at times (Devries & Zan, 1994). Each of these conditions are present in a powerful form of classroom discourse called exploratory talk (Barnes, 1992, 2008; Mercer, 1995).

EXPLORATORY TALK

OVERVIEW

The construct of exploratory talk has been influential in education primarily in the United Kingdom and Australia since the 1970's (Wegerif, 2005). Barnes and Todd (1977) introduced the term 'exploratory talk' as they examined collaborative inquiry that transpires in small group work. Barnes (2008) defines exploratory talk as "hesitant and incomplete because it enables the speaker to try out ideas, to hear how they sound, to see what others make of them, to arrange information and ideas into different patterns" (p. 5). Barnes notes that he did not mean to overemphasize small group discussions. Rather, "I was more interested in finding out how young people use talk as a tool of thinking in the absence of adult guidance" (p. 7). He suggests that exploratory talk requires preparation by the teacher as well as support and guidance. In addition, it needs to embedded in other patterns of communication such as setting ground rules for talk and promoting a community of learners.

Neil Mercer furthered the development of exploratory talk and its application to the classroom setting (Wegerif, 2005). In his research on collaborative work, Mercer

(1995) identified three types of talk, including: 1) cumulative talk in which students build upon each other's ideas in an uncritical manner; 2) disputational talk in which students engage in disagreements and are individually-minded; and 3) exploratory talk in which students engage critically but constructively with others' ideas (p. 104).

Mercer (1995) claims that these types of talk are actually "three distinctive modes of thinking" (p. 104) which people use to think and reason together. Cumulative talk emphasizes the group identity. Participants are focused on sharing with one another without criticism. Disputational talk, however, reflects a competitive orientation focused on individual identity. Exploratory talk goes beyond the individual or group identity to emphasize the process of collaborative inquiry (Wegerif & Mercer, 1997). It enables students to co-construct meaning while at the same time, critically assess that meaning. While all three types of talk can be effective ways of communicating in the classroom, Wegerif and Mercer suggest that exploratory talk is a more powerful form of communication because it provides the greatest opportunity for cognitive development.

FINDINGS

Several significant studies were revealed which suggest exploratory talk increases levels of reasoning in children (Mercer & Wegerif, 1999; Wegerif, Littleton, Dawes, Mercer & Rowe, 2004). Mercer and Wegerif found that children's scores on reasoning problems increased after they engaged in exploratory talk. The researchers developed a series of classroom lessons designed to facilitate exploratory talk. Each lesson introduced a ground rule for fostering exploratory talk, such as trying to reach agreement with other group members. In addition, a small group activity took place after each lesson. The research was conducted in three middle schools in the United Kingdom utilizing a mixed-methods design study.

Four classrooms implemented the series of lessons and were matched with four control groups in terms of socioeconomic status and age. The control classrooms carried out normal curricular activities along with small group work. All participants were given a well-known reasoning test prior to and at the end of the project. In addition, each classroom identified a focal group that represented what the teachers felt was the overall ability of the class. These focal groups were videotaped at the end of the research project as they completed the reasoning test in small groups. The researchers found that students from the experimental groups were significantly better able to solve problems on the reasoning test than the control group.

While the previous study examined exploratory talk in older students, Wegerif et al. (2004) found similar results in their quasi-experimental study on six- and seven-year olds in the United Kingdom. Called the "Thinking Together" approach, the program utilized a series of lessons in which the teacher modeled exploratory talk during whole-group and small-group discussions. Three schools were selected to implement the program and were matched with three control schools. All of the schools involved were identified as having a large percentage of under-achieving students. Many of the students involved were learning English as a second language.

The research purpose was to examine the impact of collaborative inquiry on individual development. Students were given a well-known reasoning test at the beginning and end of the study. Focal groups were selected from each classroom and videotaped throughout the project to provide data about changes in language use. In addition, interviews were conducted with teachers in the experimental schools regarding the impact of the research. Results indicate that students in the experimental schools scored significantly higher on the reasoning test than their peers. In addition, analysis of teacher interviews and discourse suggest that interactions in the classroom improved significantly, especially for at-risk students. The researchers state that “a focus on the quality of talk in the classroom may have the potential to improve the inclusion of potentially marginalized children into the mainstream of classroom activity” (Wegerif et al., 2004, p. 155).

A similar study was carried out with fifth and sixth grade students in a school in Mexico which examined exploratory talk and children’s argumentation (Rojas-Drummond & Zapata, 2004). While similar results were found in terms of students’ increased reasoning ability, the researchers note that facilitating exploratory talk requires skill by the teachers as they scaffold the learning experience. The adult must allow the students to individually construct the knowledge through probing questioning or “cognitive challenges” (p. 554) while abstaining as much as possible from giving the correct answer. This help is gradually withdrawn as students become more capable.

Others have added to the knowledge base on exploratory talk including the Brookline Teacher Researcher Seminar (Michaels, 2004). This inquiry community began in 1989 with the combined efforts of university researchers and practicing teachers who examine language and literacy in classroom settings. The primary purpose of the community is to examine children’s understandings through their talk in areas of literacy such as writing (Swaim, 2004), storytelling (Griffin, 2004), or reading aloud (Ballenger, 2004). After taping their students’ talk, the tapes and transcripts are brought to the seminar and discussed. The researchers find that the practice of studying the transcripts as data has given them insight into their students' understandings as well as viewing the co-constructions of knowledge that develop through talk. In addition, a key component has been identifying what they missed or misjudged about their students' understandings. "The work seemed to create a space for talking honestly about puzzles, frustrations, mistakes" (Michaels, 2004, p. ix) which leads them back into the classroom with new questions in light of their new understandings.

IMPLICATIONS

Research would seem to suggest that when children engage in exploratory talk, their ability to reason improves (Barnes, 1992; 2008; Mercer, 1995; Mercer & Wegerif, 1999; Rojas-Drummond & Zapata, 2004; Wegerif, 2005; Wegerif et al., 2004). Reasoning can be defined as making sense of a situation and is essential to understanding (Ball & Bass, 2003). In addition, exploratory talk can promote insight into what children know, allowing teachers to plan meaningful activities that can foster knowledge construction (Ballenger, 2004; Griffen, 2004; Michaels, 2004; Swaim, 2004).

However, some research (Rojas-Drummond & Zapata, 2004) suggests that facilitating exploratory talk can be difficult as teachers must be able to carefully scaffold the students' talk. DeVries (2000) cautions that scaffolding can lie more in the behaviorist realm unless attention is given to the type of guidance a teacher gives the students. She recommends that teachers move away from a more authoritarian role towards a "cooperative role" (p. 210). Consequently, research is needed to define what scaffolding based on constructivist theory should look like.

An overview of the research on exploratory talk reveals that the majority of research has not been conducted in the United States, but instead in other countries including Mexico (Rojas-Drummond & Zapata, 2004) and the United Kingdom (Mercer & Wegeriff, 1999; Wegerif et al., 2004). Furthermore, research conducted in the United States has primarily been done in the areas of literacy (Ballenger, 2004; Griffen, 2004; Michaels, 2004; Swaim, 2004). Exploratory talk has been found to increase a student's reasoning ability, which is essential to mathematics (Ball & Bass, 2003; Battista, 1991; NCTM, 2000). "Mathematical reasoning is as fundamental to knowing and using mathematics as comprehension of text is to reading" (Ball & Ball, 2003, p. 29). It would be beneficial to add to the theory base by examining American students. However, to determine how exploratory talk fits with existing theory and research on mathematical discourse, a review of the literature is required.

MATH TALK

OVERVIEW

> Students' discourse is an invaluable resource. It can lead to a deeper understanding of the mathematics embedded in problems and may launch new investigations. It offers opportunities for students to develop their reasoning abilities as they challenge and defend ideas. Finally, it gives teachers insights into students' thinking that can in turn be valuable in making instructional decisions (Greenes, Dacey, Cavanagh, Findell, Sheffield & Small, 2003, p. 6).

The role of talk in mathematical development is an area of increased interest in research (Cobb, Wood, & Yackel, 1993; Mercer & Sams, 2006; NCTM, 2000; Sarama &

Clements, 2006a; Whitin & Whitin, 2003). NCTM (2000) designated communication as one of ten standards for school mathematics. Stating that math talk makes "mathematical thinking observable" (p. 128), the act of organizing and clarifying personal thoughts and actions allows students to 'slow down' their thinking processes as they relay their ideas to others. To facilitate classroom discourse, students need opportunities to share their mathematical reasoning with one another (Greenes et al., 2003). This can occur in small group, partner activities, and whole group lessons where students "share their findings, make generalizations, and explore alternative approaches" (p. 5) with one another.

Problem-solving activities in particular can lead to rich discussions (Carpenter, Fennema, Franke, Levi, & Empson, 1999; Chapin et al., 2003; NCTM, 2000). NCTM maintains that problem-solving is a primary way of developing mathematical knowledge. Students are able to apply skills and mathematical concepts as they solve meaningful problems related to classroom life (Copley, 2000). Selection of appropriate problems is also important (Schifter, 2005). Teachers should pose a problem in which they expect the students to find an answer. The teacher's role is to pose questions "that will lead them through—rather than around—puzzlement to the construction of important mathematical concepts" (p. 86).

Young children are natural problem-solvers (NCTM, 2000). Educators must foster young children's innate abilities to solve meaningful problems by building on their prior knowledge (Chaille & Britain, 1997; NCTM, 2000). Other researchers have noted the ability of young children to solve meaningful problems (Carpenter et al., 1999). Students in Cognitively Guided Instruction [CGI] classrooms have been found to solve complicated word problems without explicit instruction. Rather, the students develop their own strategies which become increasingly sophisticated. During discussion time, students can demonstrate how they solve a problem or simply share their strategy with the class. This becomes a rich source of information as students' misunderstandings may be revealed (Chapin et al., 2003)

However, Gould (2005) contends that educators barely tap into the potential of using children's talk. "The teacher's role is usually to ask the questions and the children's role is to answer them" (p. 101). Other researchers have found an overemphasis on correct answers, which they suggest is not the same as conceptual understanding (Fosnot & Dolk, 2005). Teachers need to dig deeper through probing questions, asking students to share how they know or how they solved the problem. Teachers may also attempt to control the flow of students' talk, limiting any real role they can play in the interaction (Pratt, 2002).

Barnes (2008) suggests that educators interact with their students based on how they believe knowledge is developed. If teachers view their role as "transmission of authoritative knowledge" (p. 8), the talk that follows is primarily presentational. Barnes defines presentational talk as talk that typically has a predetermined answer in mind. Students respond to a teacher's question over familiar material, often guessing until the right answer is identified (Cobb et al., 1993).

Other researchers have found that not all classroom talk is high quality, especially in mathematics (Chapin et al., 2003; Solomon & Black, 2008). In many classrooms, the Initiation-Response-Evaluate discourse pattern is the norm (Cazden, 2001; Cobb et al., 1993; Mercer, 1995). The teacher begins with a question, students respond, and the teacher evaluates or provides feedback. Cazden notes that the most consistent criticism of this approach lies in the nature of the teacher's initial question. The question is "inauthentic" (p. 46) as the teacher already has an answer in mind. Cobb et al. contrast this to a information-seeking question in which the teacher genuinely desires to know the answer.

Other research supports this divergence (Bullen, Moore & Trollope, 2002; MacMahon & Raphael, 1997; Pratt, 2002; Wells, 1986; Zahorik, 1971, as cited in Lindfors, 1999). In more traditional settings, most interactions involve teacher-led questioning that is simply probing for the correct answer (MacMahon & Raphael, 1997). Zahorik states "for far too long schooling has been a matter of answering questions that children never asked" (Lindfors, 1999, p. 155). However, constructivists believe that such interactions stifle learning and the development of literate thought. Students must be given the opportunity to articulate, clarify, and expand their ideas with others. Cazden (2001) suggests the use of what she terms a "non-traditional" (p. 48) discourse pattern in which the teacher poses a question, but student and teacher responses do not fit the traditional I-R-E structure. Rather, the teacher is not focused on giving explanations. Instead, questioning and probing occurs as "the questions more often than not appear to elicit, rather than allay or forestall, confusion" (Schifter, 2005, p. 83).

One example of an alternative discourse pattern is exploratory talk (Cazden, 2001; Pratt, 2002; Solomon & Black, 2008). Pratt proposes that in mathematics, exploratory talk in particular promotes meaningful classroom interactions that engage students' thinking. He distinguishes between "mathematical thinking" and "mathematics as thinking" (p. 35). Mathematical thinking emphasizes a particular knowledge that the teacher wants the students to develop. In mathematical discussions, all talk leads back to a particular concept the students must master. Mathematics as thinking, however, focuses on the centrality of thinking which is necessary for understanding mathematics. Cobb et al. (1993) also cautions against math talk in which students engage in a guessing game to identify the procedure the teacher has in mind. Rather, “the teacher’s role is to initiate and guide a genuine mathematical dialogue between the students” (p. 93).

FINDINGS

An examination of research on mathematical talk identifies one study in particular that does not fit the criteria of recent research. However, it articulates related phenomena relevant to the topic and will be addressed in several sections of the review. Cobb et al. (1993) examined mathematical discourse and its role in cognitive development in a second grade classroom using a mixed-methods research design. The following school year, the study was implemented into seventeen additional classrooms. Instruction consisted of small-group work followed by a whole-group discussion of problem-solving strategies. Videotapes of whole group lessons were collected as well as individual interviews with students. In addition, written work, field notes, and teacher interviews were gathered. A state-mandated assessment was taken by all second grade students at the end of the year. Assessment results indicate that the performance of students involved in the project was significantly superior to non-project students on questions over conceptual knowledge. On the computational component of the assessment, project and non-project student scores were similar.

Research by Chapin et al. (2003) also examined how classroom discussions can be the center of mathematical learning. The study, Project Challenge, was funded by the U.S. Department of Education and looked at ways to increase the low percentage of minority students in gifted and talented programs. The hypotheses was that a reform-minded mathematics curriculum based on reasoning and communication would enable such students to succeed. Approximately one hundred fourth graders were selected to participate in the program, based on teachers' recommendations, work samples, and prior math achievement. Four classrooms were created which closely matched the demographics of other students in the district. A constructivist-based curriculum was implemented along with the strategic use of classroom talk.

Initially, students were reluctant to engage in discourse. However, as the program continued, their language became much more sophisticated. In addition, students' mathematical reasoning increased as indicated by standardized test scores. At the beginning of the program, only four percent of the students were rated as superior in mathematics. After two years in the program, forty-one percent were rated superior. The researchers conclude that productive talk allows students to think out loud and enables minority students to be "mathematically articulate" (p. xiii). They suggest however that most classroom talk is unproductive and "lecturing, recitation, and quizzing" (p. 5) continue to be primary tools. The researchers recommend ways to implement productive math talk, such as creating a respectful environment, providing opportunities to talk about math, and identifying new social norms related to math talk.

IMPLICATIONS

Classroom talk would seem to support mathematical learning (Chapin et al., 2003; Cobb et al., 1993; NCTM, 2000; Pratt, 2002; Schifter, 2005). As classrooms move away from traditional instruction towards reform-minded teaching, opportunities for meaningful mathematics discussions can occur. However, Hodgkinson and Mercer

(2008) state that “we have the practical knowledge needed to improve the quality of classroom talk. Yet, in most classrooms . . . talk remains a taken-for-granted feature of everyday life” (p. xvii). Chapin et al. agree, suggesting that most classroom math talk is not high quality. In classrooms where mathematical discourse may have been implemented, opportunities for real interaction on the part of the students continue to be stifled by the teacher who may be teaching from a more behaviorist stance (Barnes, 2008) or feels pressured to meet district or state-level mandates (Cobb et al., 1993; Pratt, 2002).

Furthermore, in examining Chapin et al.’s (2003) findings, a concern arises with their recommendations for supporting classroom discourse. While the suggestions seem sound, Fosnot’s (2005) caution of teaching without theory comes to mind. Educators need an underlying theory that drives how language is viewed in the classroom. If teachers simply accept teaching strategies without such an understanding, “a cookbook faddism” can result (p. ix). Exploratory talk is more than superficial reform. It is grounded in theory and research, altering the role of language in the classroom. It has much to contribute to promoting meaningful mathematical discourse, resulting in its inclusion in this research study. Such inclusion, however, requires first an understanding of how the classroom community is built around math talk.

MATHEMATICAL DISCOURSE COMMUNITY

OVERVIEW

> When a teacher succeeds in setting up a classroom in which students feel obligated to listen to one another, to make their own contributions clear and comprehensible, and to provide evidence for their claims, that teacher has set in place a powerful context for student learning (Chapin et al., 2003, p. 9).

A mathematical discourse community is a respectful classroom environment in which the teacher and students use discourse to support mathematical learning (Hufferd-Ackles, Fuson & Sherin, 2004). NCTM (2000) recommends that teachers create a community where students are able to share their mathematical thinking coherently with peers and teachers. However, creating such an environment takes time (Hufferd-Ackles et al., 2004). Procedures need to be put in place to foster productive talk (Chapin et al., 2003). These can include establishing ground rules to ensure a respectful environment (Meyers, 1995). Ground rules can also redefine classroom norms which govern behavior (Yackel and Cobb, 1996). In addition, a mathematical discourse community changes the roles of teachers and students as they listen, paraphrase, and interpret each other's ideas in a variety of student groupings designed to allow opportunities for collaborative inquiry.

FINDINGS AND IMPLICATIONS

Hufferd-Ackles et al. (2004) describe levels and components of a classroom mathematical discourse community. Utilizing a qualitative research design, the researchers initially videotaped four elementary classrooms as they established a mathematical discourse community based around a constructivist math program. The third grade classroom in particular showed remarkable progress and was selected to participate in a case study the following school year. Videotapes were collected as the teacher and students engaged in mathematical discourse. After transcription, the discourse analysis reveals what they call a "developmental trajectory" (p. 87) in which teacher and student actions were linked to the development of the classroom community. They found that teachers typically move from a more traditional stance to that of co-learner and coach. Students generally begin by giving short answers with no explanation to that of defending and justifying their work. The authors conclude that "the classroom community grows to support students acting in central or leading roles and shifts from a focus on answers to a focus on mathematical thinking" (p. 88).

What is not mentioned in the research is what is revealed about student mathematical knowledge through their talk. NCTM (2000) maintains that as teachers seek to understand what the students are communicating, information can be gathered to advance the individual students' thinking. As math reform moves teachers away from traditional methods of instruction and assessment, it is imperative that research identifies if these more interpretive forms of analysis reveal a clearer picture of a child's reasoning ability.

The findings by Hufferd-Ackles et al. (2004) emphasize that building a mathematical discourse community takes time. Teacher and student roles are reformed as individuals learn to support each other through their math talk. They provide a continuum demonstrating how a discourse community was created in one classroom. However, these implications were drawn from research on older students, suggesting a need to examine how a mathematical discourse community is created in an early childhood classroom.

Ground Rules

Various connotations of the term 'ground rules' exist. Chapin et al. (2003) define ground rules as conditions necessary for respectful talk and suggest that they be put in place prior to implementing a mathematical discourse community. They find that ground rules are essential for promoting an atmosphere of respect to ensure that students can share their mathematical thinking without fear of ridicule or rejection. They provide a list of suggested ground rules to implement.

Mercer (1995) also discusses the importance of ground rules. He cites data from a research project he was involved in called SLANT [Spoken Language and New Technology]. The aim of the research was to examine collaborative talk among students in the United Kingdom. He notes that much of the early research was disappointing as students rarely engaged in exploratory talk. Consequently, a whole-group discussion time was implemented where students and teachers discussed what should take place during talk time. These ground rules were then utilized during small-group activities. The results of the research indicate that the addition of ground rules that were constructed by both the teacher and students fostered exploratory talk. Ground rules can include reaching agreement as a group, accepting group responsibility for ideas, and listening to everyone's ideas.

Wheeldon (2006) also utilized student-made ground rules in a teacher research project on exploratory talk in the United Kingdom. The rules were referred to throughout the project and adapted to reflect students' growing sophistication with exploratory talk. She concludes that the use of ground rules led her class to become more independent in their talk.

The use of ground rules would seem to support exploratory talk (Mercer, 1995; Wheeldon, 2006), necessitating inclusion in this research project. In addition, ground rules can shape how the students and teacher respond to one another, establishing new social norms for mathematical learning (Cobb et al., 1993).

<u>Social Norms</u>

Social norms are rules that a group uses to define appropriate and inappropriate behavior that transpires in the classroom (Yackel & Cobb, 1996). These norms may be overt or covert and are based on the teacher's theory of knowledge. Norms govern and influence how subjects are taught. Yackel and Cobb (1996) distinguish between social norms and sociomathematical norms. Sociomathematical norms emphasize what is acceptable behavior for mathematical learning. In mathematics based on constructivist theory, sociomathematical norms might include explaining strategies, justifying answers, and peer collaborations. They suggest that through mathematical discourse, the students and the teacher interactively construct a taken-as-shared understanding of what is valued mathematically.

> In responding to the teacher's request for different solutions, the students were simultaneously learning what counts as mathematically different and helping to constitute what counts as mathematically different in their classroom . . . The teacher's responses and actions constrained the students' developing understanding of mathematical difference and the students' responses contributed to the teacher's developing understanding (p. 462).

In a mathematical discourse community, Cobb et al. (1993) suggest that classroom norms may be renegotiated as the teacher and students learn how to engage in mathematical talk. In their research on second grader's math talk, they discovered two interdependent levels of conversation. They term these types of talk "talking about mathematics" and "talking about talking about mathematics" (p 96). Talking about mathematics includes sharing and justifying strategies for solving problems. It does not fit the typical discourse pattern of Initiation-Response-Evaluate. Talking about talking about mathematics, however, is conducted using the I-R-E format. However, teachers are able to use their authority to develop new mathematical traditions: one where students are able to "say what they really thought mathematically" (p. 99). Cobb et al. suggest that these new norms change not only future whole-group and small-group discussions, but also how students engage in mathematical activities.

Awareness of social norms that govern mathematical learning is crucial to the success of this research project. While recognizing that students individually construct mathematical knowledge, the environment--which includes students, the teacher, and how they interact according to social norms--affects the student's understandings. Consequently, social norms must be analyzed to determine what role they play in the learning process.

In addition, Yackel and Cobb's (1996) research maintains that taken-as-shared meanings influence what is viewed as mathematically relevant. However, they do not address the mathematical learning that transpires as students co-construct or build learning collaboratively. For the purposes of this research study, classroom discourse will be examined that may reveal how the support of others, namely teachers and students, led to a deeper understanding of mathematical concepts.

Teacher and Student Roles

> The traditional hierarchy of teacher as the autocratic knower, and the learner as the unknowing, controlled subject studying and practicing what the teacher knows, begins to dissipate as teachers assume more of a facilitator's role and learners take on more ownership of the ideas (Fosnot, 2005, p. ix).

The establishment of a mathematical discourse community requires a transformation of the role of the teacher and the students (Chapin et al., 2005; Fosnot, 2005; Mercer, 1995). For teachers, Schifter (2005) maintains that fostering discourse is no easy task. “It depends on one’s capacity to respond spontaneously to students’ perplexities and discoveries” (p. 88). In the older grades, students can take on more responsibility in the discourse community as they listen and respond to each others’ ideas (NCTM, 2000). However, it can be difficult to sustain a whole-group discussion with younger children (Greenes et al., 2003). Suggestions to make large group talk more meaningful include extending wait time to allow students to comment, use of probing questions rather than comments, and allowing students to correct each other when errors occur rather than the teacher. Young children can also have difficulty seeing others’ perspectives (NCTM, 2000). Students need help sharing their ideas clearly with others. This can be done by “revoicing” (p. 12) or restating what the child is saying as well as encouraging other children to paraphrase the response (Chapin et al., 2003).

Barnes (1992) suggests that the teacher’s role in facilitating talk is to reply, not assess. To reply means that the learner’s response is taken seriously by the teacher. The student feels comfortable discussing ideas in a collaborative relationship with the teacher. However, when assessed, the student-teacher relationship becomes distanced as the student’s response is weighed and measured against a predetermined condition. “If a teacher stresses the assessment function at the expense of the reply function, this will urge his pupils towards externally acceptable performances, rather than towards trying to relate new knowledge to old” (p. 111).

In addition, teacher modeling has been found to foster talk (Wheeldon, 2006). Wheeldon found that the quality of six-year-olds' mathematical talk improved through explicit modeling of exploratory talk. At the beginning of the study, students' mathematical conversations were brief and teacher-directed. After identifying ground rules for math talk, student groups engaged in weekly problem-solving tasks. The teacher met with individual groups and made statements and comments designed to promote exploratory talk. The teacher gradually withdrew support as students became able to engage on their own in exploratory math talk.

Changing student and teacher roles is primary in establishing a mathematical discourse community (Chapin et al., 2005; Fosnot, 2005; Mercer, 1995). Students must play an active role in discussions (Barnes, 1992). Teachers must support learners as they talk and discuss mathematical ideas, attempting to engage with students collaboratively (Barnes, 1992; 2008). Wheeldon's research in particular has implications for the current research study. As the research question is focused on students' exploratory math talk, every effort must be taken to ensure that such talk transpires through the implementation of teacher modeling. This will enable students to become increasingly able to engage in exploratory talk on their own in whole-group and small-group discussions.

Student Groupings

Chapin et al. (2003) identify three productive talk formats, including whole-group discussions, small-group discussion, and partner talk (p. 17). They emphasize whole-group discussions, noting that it can be difficult for students to engage in meaningful talk on their own. In a large group format, the teacher is able to facilitate and guide discussions. However, Littleton (1998), drawing on research by Piaget, suggests that power relationships can influence the type of talk that occurs in the classroom. An adult presence can alter student learning as children tend to have difficulty balancing their views against those of adults. She recommends that students have opportunities to engage in peer talk as a way to form more symmetrical relationships.

Mercer (1995) also finds that smaller collaborative groups may foster talk, but he questions the type of talk that occurs. He suggests that students receive guidance on how to use talk effectively, especially exploratory talk. For the purposes of this research study, both whole-group and small-group discussions will be used. Explicit modeling of exploratory talk will take place in a whole-group setting. In small-groups, I will act as a facilitator but gradually lessen my role as students become more capable on their own.

SUMMARY

Exploratory talk draws together research and theory on what productive discourse should sound like (Barnes, 1992, 2008; Cazden, 1992; Chapin et al., 2003; Fosnot, 2005; Mercer, 1995; NCTM, 2000; Wegerif & Mercer, 1997). In mathematics in particular, it engages students in critical, but constructive engagement with others' ideas (Solomon & Black, 2008). Students share ideas, engage in mutual decision-making, clarify comments, and present alternative explanations while solving meaningful math problems. As students argue and defend their answers in a discourse community, they are "co-operating" with peers and their teacher (Kamii, 2000a). Furthermore, its link to increased reasoning (Mercer & Wegerif, 1999; Wegerif et al., 2004, Rojas-Drummond & Zapata, 2004) seems to suggest that this form of discourse is necessary for fostering mathematical conversations worth having in the classroom (Chapin et al., 2003; NCTM, 2000).

However, exploratory talk, while a well-established educational theory in the United Kingdom (Barnes, 1992, 2008; Mercer, 1995, Wegeriff, 2005), has not been fully examined in the United States (Mercer & Wegerif, 1999; Rojas-Drummond & Zapata, 2004; Wegerif et al., 2004), especially in the area of mathematics (Ballenger, 2004; Griffen, 2004; Michaels, 2004; Swaim, 2004). This omission of a well-supported language theory, I believe, is a detriment for students as well as teachers who may be unfamiliar with using language as a means of learning (Barnes, 1992).

This lends itself to the current research topic. As I sought to understand my students' mathematical knowledge through analysis of their talk, I hoped to glimpse not only their constructions of knowledge, but what I might have missed during the interaction. Furthermore, such analysis may reveal how their taken-as-shared meanings supported their individual constructions (Cobb et al., 2003; DeVries, 2000; von Glasersfeld, 2005).

Such an undertaking required an emic perspective (Merriam, 1998). My puzzlement was my own. My continual refining of the question is what drove the research process. As I learned more and more about my students through their words, I hoped to put into play opportunities to further their mathematical knowledge.

CONCEPTUAL FRAMEWORK

Learners construct mathematical knowledge through their interactions with physical and social aspects of their environment (Kamii, 2000a). While these constructions are uniquely their own, they are impacted by the social world of the classroom. In a constructivist-based mathematical discourse community, opportunities to share, reason, and build on others' ideas can be fostered through a special form of discourse called exploratory talk. Exploratory talk is filled with hesitations, “uhs”, repetition, and other examples of incomplete speech (Barnes, 1992). Students grapple out loud with problems as they co-construct meaning. These co-constructions are actually individual interpretations of the phenomena (DeVries, 2000). However, through the very act of argumentation, conflict, and collaborative inquiry, students’ reasoning abilities may increase. Thus, analysis of classroom discourse was necessary to provide insight into children’s mathematical knowledge, which can include understanding of number and operations, geometry, measurement, data analysis, and algebra (Clements, 2004). Such analysis might reveal how student math talk is supported by others, including teachers and peers, while providing a context for understanding the impact of social norms on mathematical learning during math time and throughout the classroom day.

CHAPTER III

METHODOLOGY

INTRODUCTION

The purpose of this study was to understand what Kindergarten students reveal through their exploratory math talk. In understanding this phenomenon, the study addressed five research questions: (a) What mathematical concepts are present in Kindergarten students' exploratory talk?, (b) What does exploratory math talk sound like in Kindergarten students?, (c) When do students engage in exploratory talk?, (d) In what ways are students supported in their math talk?, and (e) How are social norms reflected in mathematical conversations?

The research methodology is described in detail in this chapter and includes discussion on the following: (a) rationale for research approach, (b) research participants and setting, (c) research design, (d) data collection methods, (e) analysis and synthesis of data, (f) ethical considerations, and (g) issues of trustworthiness. A brief summary concludes the chapter.

RATIONALE FOR QUALITATIVE RESEARCH DESIGN

Research can be defined as engaging in systematic inquiry to understand phenomenon (Stringer, 2004). Two major paradigms can be used to investigate the problem, namely quantitative and qualitative research. Quantitative approaches allow the researcher to disengage from the phenomena being studied. Utilizing precise measures and controlling for events, the researcher seeks an explanation for the occurrence. Qualitative research, however, engages naturalistic inquiry in understanding the event (Marshall & Rossman, 2006). Recognizing the complexity of human life, qualitative researchers seek to investigate the meanings that are constructed (Stringer, 2004). Emphasis is placed on the natural setting, which can include the classroom in educational research (Lankshear & Knobel, 2004).

Quantitative methods seemed unlikely to elicit the rich data needed to understand this research topic. Recognizing that mathematics is both an individual as well as a social activity, a qualitative stance promotes understanding of the students' mathematical constructions as well as the contextual elements influencing their learning. In addition, the key assumptions that distinguish qualitative research corresponded well with this study, including: (a) an emphasis on understanding the meaning of what has been constructed; (b) utilization of an inductive form of reasoning; (c) a rich description of findings; and (d) the central role of the researcher in data collection and analysis (Merriam, 1998). Through this research project, understanding of the meanings students have constructed was sought. Rather than testing an existing theory, this research built towards theory utilizing observations and intuitive insights. In addition, the students' own words conveyed both their understandings as well as supported the research findings. Finally, I gathered and analyzed the data, serving as the primary instrument in the process.

RATIONALE FOR TEACHER RESEARCH METHODOLOGY

A teacher research design was used to provide illuminating insights into a Kindergarten classroom with the teacher (myself) acting as the participant researcher.

Teacher research enables educators to disseminate research conducted in their own settings (Lankshear & Knobel, 2004; Mohr, Rogers, Sanford, Nocerino, MacLean, & Clawson, 2004). This research is different from more traditional types as it promotes a way for educators to generate knowledge and add to the research base on teaching and learning (Cochran-Smith & Lytle, 1999). Typically, research influencing education has been conducted at the university level. Yet this practice ignores the significant contributions that teacher knowledge can provide which may radically challenge what is known about education (Cochran-Smith & Lytle, 1993). When teachers are engaged in research, they are promoting change from within which can be a powerful form of professional development. This process may alter the notions of power in education, challenging commonly-held assumptions about theory, practice, and reform (Cochran-Smith & Lytle, 1999).

In addition, teacher researchers have established relationships with their students, increasing the likelihood of gathering authentic child responses (Stremmel, 2007). This knowledge provides a distinct advantage over outside researchers who may be unfamiliar with the classroom community and problems of daily practice. Finally, teacher research benefits the field of early childhood education by promoting the development of early childhood professionals and their ability to be responsive to the needs of their students (Bredekamp, 2004). Through research, "teachers develop new ways of seeing students and develop stronger understandings of children's feelings and growth" (Henderson, Meier, & Perry, 2004, p. 1).

This study fit well with teacher research because I sought to understand how children's mathematical discourse can provide access to their thinking. This question emerged from my role as a teacher as I experienced conflict between theory and practice (Cochran-Smith & Lytle, 1993). Theory suggested making connections with my students' informal mathematical knowledge. However, in daily practice, I found it difficult to fully understand a child's conceptual knowledge.

RESEARCH PARTICIPANTS

This research study was designed to learn more about my students' mathematical abilities. Thus, sampling procedures were not applicable. However, research in general acknowledges the difficulty in applying positivist paradigms to educational settings (Cochran-Smith & Lytle, 1999). I was researching what math talk looks like and sounds like in my own students, necessitating the selection of my assigned class.

Twenty-two students were in the classroom at the start of the project representing various ethnicities, including Native American (1), Hispanic (5), African American (4), and Caucasian (12). All students were given parental permission to participate in the research study which included twelve boys and ten girls. Four students were classified as English Language Learners. The classroom was considered a class within a class due to two special education students. A full-time special education paraprofessional worked in the classroom along with the regular teacher. The school experiences frequent student movement; one student moved shortly after the research project began. Two additional students moved at the midpoint in the project. Table 3.1 provides an overview of the participant demographics at the beginning of the project.

Table 3.1 Participant Demographics Matrix

Participant (Pseudonym)	Age	Gender	Ethnicity	English As Second Language?
Aaron	6	Male	Caucasian	No
Adriana	5	Female	Caucasian	No
Alex	6	Male	Hispanic	Yes
Alvin	6	Male	Hispanic	No
Chris	6	Male	Native American	No
Colby	6	Female	Caucasian	No
Ivan	6	Male	Hispanic	Yes
Jacob	5	Male	Caucasian	No
Jamie	5	Male	Caucasian	No
Javier	6	Male	Hispanic	No
Justin	5	Male	African-American	Yes
Kara	5	Female	Caucasian	No
Kayla	6	Female	African-American	No
Kristina	6	Female	Caucasian	No
Madison	5	Female	Caucasian	No
Megan	5	Female	Caucasian	No
Mia	5	Female	Hispanic	Yes
Michael	6	Male	Caucasian	No
Stacey	5	Female	African-American	No
Steven	5	Male	Caucasian	No
Tiara	5	Female	African-American	No
Todd	5	Male	Caucasian	No

School Setting

The research study took place in an all-day Kindergarten classroom in a public elementary school that is part of a large Midwestern urban school district. The school is relatively small with approximately four hundred students, the majority of which live in the neighborhood. The school population consists primarily of middle-class and working-class families. In recent years, neighborhood demographics have changed with an increasing number of English Language Learners. The school receives Title One funds due to a high percentage of students who receive free- and reduced-lunch.

Classroom Setting

The classroom utilized a district-adopted mathematics curriculum, Investigations, that is constructivist based. Students are encouraged to problem-solve and discuss as they participate in a variety of investigations designed to develop mathematical knowledge. Thus, the research topic fit well with the adopted curriculum. These investigations were utilized for both large and small group work throughout the research study in addition to other activities deemed appropriate by the teacher. Classroom routines were not significantly altered during the course of the research study as students had been exposed to both whole- and small-group math activities. In addition, math talk had been introduced informally in accordance with the school district curriculum.

OVERVIEW OF RESEARCH DESIGN

The twelve-week investigation began in February, 2008. The following steps were taken to conduct the project. An in-depth discussion of key procedures will follow to promote understanding of the procedures.

- Prior to beginning the study, a review of the literature on exploratory talk and classroom discourse was conducted to determine appropriate theory guiding the project as well as contributions of other researchers to the topic.
- Approval to perform the research was given by the building principal and the school district.
- After initial support of the dissertation proposal, approval was sought from the IRB to proceed with the research. The IRB process requires researchers to outline the procedures needed to ensue adherence to strict standards on working with human subjects. Approval was granted (see Appendix A).
- I talked personally with each participant's family to inform them of the study utilizing a script (see Appendix B). They were informed that all students would participate in the activities. However, data would be gathered only for those students who had parental permission. A translator was not needed as each family had at least one parent who spoke English and did not request translation.
- The parent permission forms (see Appendix C) were sent home with each student in a sealed envelope. A translated parental permission form was not required. All students returned their forms giving parental consent.
- Four student groups were formed. The number of groupings was selected to allow weekly discussion times that fit within the constraints of the classroom schedule. The groups were based on friendship patterns in the classroom (Barnes & Todd, 1977). As I wanted to encourage exploratory talk, groups contained students who usually worked well together, but were not best friends (Mercer, 1995). In addition, groups were similar in size and mathematical ability to

promote understanding across groupings. Variables such as gender, ethnicity, and classroom behavior were also considered to form heterogeneous groups. Students that seemed to engage more in discussion were spread out among the groups.

- Assent from each participating child was obtained by individually calling each child to the back area in the classroom and following a script (see Appendix D). This was completed prior to taping each time data were collected. Students that did not give their assent sat outside the range of the video camera and were not grouped with study participants during small-group work. The percentage of students who did not give their assent was small, typically one student every few weeks. However, one student in particular did not give assent to participate throughout the study.
- Prior to beginning data collection, I introduced the research topic to the class and explained how the students would help me learn what they knew about mathematics through their talk.
- Once the study began, students identified ground rules for participating in math talk during whole-group and small-group math activities. These rules were posted in the classroom and added to throughout the study.
- During whole group instruction, I posed a meaningful math problem with the class. Students discussed the problem and identified possible strategies to solve it. I attempted to facilitate exploratory math talk utilizing open-ended statements and questions designed to engage students in a critical, but constructive

engagement with others' ideas. Discussions were video-taped using a wide-lens camera angle.

- The class typically worked through one strategy to solve the problem, involving students in sharing ideas, engaging in mutual decision-making, clarifying comments, and presenting alternative explanations. Occasionally, after discussing possible strategies using exploratory talk, students worked individually, with a partner, or in small groups to solve the problem. Their findings were then brought back to the group for discussion and consensus.
- During whole-group discussions, I modulated turn-taking, at times calling on students that raised their hand to talk. Other times, students were asked to respond.
- After whole-group time, students met weekly to participate in small collaborative groups as they solved a problem similar to the whole group activity. Some weeks overlapped due to shortened weeks due to holidays or other out-of-school events. Small group conversations were tape recorded. Originally, I had planned to set up a problem-solving table with a tape recorder nearby where I would work with small groups while the classroom paraprofessional facilitated the remaining students. However, after transcribing the initial tape, the level of classroom noise seriously affected the quality of data. I then moved the small group to the hallway right outside the classroom.
- Student groups were to remain fixed to promote collaboration (Meyer, 1995). However, one student moved right after the project began, requiring adjustment to

several groups. The groups remained the same throughout the remainder of the study.

- At the beginning of the study, I facilitated small-group discussions and made statements and comments designed to promote exploratory talk. Support was gradually lessened as the students became more capable of solving problems on their own.
- Student groups were able to represent the problem using a variety of manipulatives and/or drawings. Student work samples were collected to facilitate understanding of group work. In addition, photographs were taken to add important details about student conversations.
- Observations of students, including a written record of their math talk, were gathered and recorded in a teacher research journal to document use of math talk in other areas of the curriculum.
- All data were carefully transcribed and secured to protect the participants' identity.
- During the last week of data collection, the students and I discussed what we had learned throughout the research project. Conversations were video-taped.
- At the conclusion of the study, I contacted each family regarding the study results at the end of the project and to thank them for allowing their child to participate. In addition, parents received information about their own child's mathematical progress which was revealed through conversations, observations, and samples of their work. Questions about how the research would be reported were answered at that time.

PRELIMINARY PROCEDURES

Literature Review

To inform the study, an ongoing and critical review of literature was conducted. In particular, existing research on exploratory talk and classroom discourse was examined to gain a better understanding of how to support meaningful math talk in the classroom. This information was used to promote exploratory talk during whole-group and small-group discussions.

IRB Approval

After receiving approval to conduct research from the school district and building principal, I began the process of achieving IRB approval. In this research project, I held the dual role of teacher/researcher, requiring that careful attention was given to the notion of coercion. Specifically, in my research plan, I acknowledged the unequal relationship between myself and the students. Additionally, I emphasized the increased responsibility that comes with the role of teacher/researcher to avoid any unknown sources of coercion which would decrease the validity of the study. Approval was granted.

Consent

Teacher researchers have established histories with the families of the students they teach (Stremmel, 2007). This required that I proceed carefully to ensure full understanding of the project as well as my own intentions to maintain confidentiality and ethical standards. As the setting of this research is a neighborhood school, I was able to meet personally with the majority of families in my classroom. Families were contacted by phone if face-to-face contact was not possible due to after-school childcare or transportation issues. A script was utilized to promote consistency in the discussion.

After initial contact, I sent home a parental permission form in a sealed envelope. The form was discussed with parents during the initial contact. Parents were informed where to sign, either granting or not granting their approval. I emphasized that all students would be participating in the math activities as they were part of the district curriculum. The permission form was to allow me to collect data for use in the study. All families returned their forms giving full consent for their child to participate.

In addition, students were asked to give their assent each time that data were collected. Prior to taping, students were called individually to the back of the room and were read a script. They then responded 'yes' or 'no'. Several times during the study, students did not give their assent to participate in the research that day. They were then seated outside the range of the camera during whole-group discussion time and were not included in the small-group collaborative work. However, the majority of students gave their assent to participate each time data were collected.

RESEARCH PROCEDURES

Introductory/review:

Prior to beginning data collection, I introduced the research project to the class. I explained that I wanted to learn more about students' understanding of math through their talk. A wide-angle video camera was stationed in a corner in the classroom. The camera was set up several days in advance of taping to allow students to become familiar with the equipment (Lankshear & Knobel, 2004).

On the first day of the project, I met with the class to brainstorm a list of ground rules on how to talk in a large group. Student ideas were recorded on a chart tablet entitled

"Talk Chart." The following examples identify the ground rules that students felt were important.

- We listen.
- Take turns.
- Don't interrupt.
- Let everyone talk.
- We are nice.

The ground rules were referred to throughout the research project. New ideas were added periodically, drawn from weekly discussions. For example, I noticed at one point that some students were having difficulty listening as other students shared their ideas. During the next discussion time, we talked about how to be active listeners such as looking at the person who is talking. The rule was added to the talk chart. The following examples were added to the original "Talk Chart" list.

- Work together on ideas.
- If you don't understand, ask.
- If you disagree, be kind.
- If someone gets stuck, help them.
- Show people you are listening.

<u>Whole Group Math Discussions</u>

Mathematical discussions were held twice a week at the onset of the project. However, at various points in the research study, only weekly discussions were conducted due to school-wide events, holidays, or special activities. After a review of the Talk Chart, I posed a meaningful math problem to the class. Students discussed the problem and identified possible strategies to solve it.

Initially, problems were drawn from the district mathematics curriculum. However, I quickly noticed a discrepancy between what theory suggested was a meaningful problem and the types of problems in the curriculum. Other resources I examined seemed to provide computational problems to solve such as identifying how many altogether. However, a key component in problem-solving is initial puzzlement (NCTM, 2000). For young children especially, problems relating to life in the classroom are more meaningful (Copley, 2000).

I began to pose problems drawn from the context of the classroom, such as determining how to count children's noses for a classroom Valentine's day party. Other ideas came from related literature. After reading a story about April Fool's Day, students had to solve a trick played on them and determine how many were in the barn based on the number of feet and tails. Others centered around classroom themes such as insects. In a writing activity, one student, Jamie, posed the question "Is a spider an insect?" Rather than respond, this question was brought to math discussion time where it was explored and consensus sought.

After posing a problem, students were asked to identify ways to solve the problem. As students shared their thinking, I attempted to scaffold their talk using components of exploratory talk. Probing questions, inviting students to agree or disagree, and building on each other's ideas were modeled for the class (Barnes, 1992). I endeavored to withhold praise or criticism, enabling students, at times, to correct others' errors. Student ideas were recorded and voted on to determine a strategy to solve the problem. Once a strategy was selected, the class and I worked together to solve the problem. Occasionally, after discussing possible strategies using exploratory talk, students worked individually, with a partner, or in small groups to solve the problem. Their findings were then brought back to the group for discussion and consensus.

Early on in the project, I noted that open-ended problem-solving was difficult for some students. I began to introduce mathematical tools that students could employ as they strategized and solved problems. Mathematical tools can include any material that students select to help model a problem, such as picture drawing, use of manipulatives, or writing (NCTM, 2000). In addition, young children seem to rely on their fingers as a tool to demonstrate understanding (Carpenter et al., 1999; Kamii, 2000a). These tools enable students to symbolize or represent their thinking. After solving a problem, the students were able to agree or disagree with the results and share their reasoning with the class.

During the discussion, I modulated turn-taking among the students. Turn-taking can be defined as the back-and-forth pattern generally found in conversations (Lindfors, 1999). However, young children are egocentric (Kamii, 2000a). They typically have difficulty being able to think from another's viewpoint, such as allowing one speaker at a time to talk (Lindfors, 1999). While recognizing that this is typical of Kindergarten students, my primary research goal was to understand individual students' mathematical talk. This required that I have evidence of their speech. Frequent interruptions, blurting out, domination by one student--all would lessen my ability to collect meaningful data. Thus, for the purposes of this research, I typically called on students that raised their hand to talk.

Other times, students were asked to respond. I utilized my knowledge as a teacher in selecting students that did not raise their hand. Some of my students were unsure about vocalizing their ideas in a large group, including English Language Learners. Rather than force them to talk, I wanted to establish a community where they would feel comfortable to engage in discourse on their own. This required at first allowing more vocal students to engage in discussion. As the research study progressed, I began to select students that did not usually share their ideas in a large group setting. If the student seemed uncomfortable, I supported his or her think time and moved on to another child. At other times, students would talk out of turn. I attempted to facilitate this, ensuring that all students were given an opportunity to voice their ideas without interruption. However, occasionally, these interruptions furthered the discussion and were thus allowed. I had to draw on my knowledge of theory to guide how I handled such occurrences, shifting back-and-forth in my role as teacher/researcher.

Small Group Math Discussions

Next, I met weekly with four small groups of students. The number of groupings was selected to allow weekly discussion times that fit within the constraints of the classroom schedule. The groups were formed based on friendship patterns in the classroom (Barnes & Todd, 1977). Mercer (1995) identifies three types of talk he found in his research, including cumulative, disputational, and exploratory. He suggests that students who have a “shared history of successful collaboration” (p. 103) tend to engage in cumulative talk which means a cooperative but uncritical engagement with others' ideas. Disputational talk includes “disagreements and individualized decision-making” (p. 104). As I wanted to promote exploratory talk, students were placed in groups who usually worked well together, but were not best friends.

In addition, groups were similar in size and mathematical ability to promote understanding across groupings. Variables such as gender, ethnicity, and classroom behavior were also considered to form heterogeneous groups. Students that seemed to engage more in discussion were spread out among the groups to facilitate conversation and ensure that all students had an opportunity to talk.

Introductory/Design Changes

On the first day of the project, I met with small groups at a table in the classroom while the other students engaged in small-group activities with the paraprofessional. However, upon transcribing the tape, I found that the quality of talk was very distorted due to the noise level. I began meeting with each small group in the hallway outside the classroom door, using a cart to hold manipulatives and additional teaching materials.

It could be argued that removing the students from the classroom to record them was creating an artificial, unnatural setting (Barnes & Todd, 1977; Lankshear & Knobel, 2004; Merriam, 1998). I did not record small group talk that occurred in the classroom. Recordings made in a classroom where twenty-two students were working were extremely difficult to transcribe due to the background noises. Furthermore, my research question was centered on understanding students' mathematical thinking through their talk. This necessitated collecting high quality samples.

Small groups were to remain fixed to promote collaboration (Mercer, 1995). However, a student, Kayla, moved right after the project began, necessitating a change in members to stabilize group size (Barnes, 1992). The groups remained the same throughout the remainder of the study. Table 3.2 details the student groupings after changes were made

Table 3.2 Small Groups (by pseudonym)

Group #1: Madison Ivan Megan Javier Tiara Kara	Group #2: Alvin Kristina Justin Jamie Steven
Group #3: Adriana Jacob Mia Stacey Alex	Group #4 Aaron Chris Colby Michael Todd

Lesson Format

The small-group lesson format consisted of sharing a problem similar to the whole-group activity by theme or mathematical content. For example, after identifying the differences between a spider and an insect during a whole group discussion, students were given the total number of legs hidden inside a mystery bag. Group members had to determine what creatures were inside the bag based on findings from their whole-group work.

Students then worked together to identify possible strategies to solve the problem. I controlled student talk primarily through turn-taking. I gradually lessened my support based on students' ability to engage in turn-taking on their own. As a group, one idea was selected and utilized to find an answer to the problem. Manipulatives and other tools could be used to model the problem. Upon group consensus, students worked together to represent their findings. These student work samples were gathered to flesh out small group discussions and stored in a locked file. To capture details and close-ups as the research participants were engaged in small group work, a digital camera was utilized.

Student Observations

Students were observed five times during the project to examine if exploratory talk occurred during other parts of the school day. Observations were recorded in a teacher research journal along with a detailed account of their discourse. Observations typically took place during classroom routines, small group activities, and whole group discussion time.

End of the Study

At the conclusion of the research study, all families were contacted either personally or by a phone call to thank them for allowing their child to participate. Information was given about their child's mathematical progress as well as how the findings would be reported.

DATA COLLECTION METHODS

The use of multiple sources of data to confirm the emerging findings is crucial to the success of a research study (Merriam, 1998). Thus, this project utilized a variety of data collection methods, including audio recordings of small group math talk, video recordings of large group math discussions, and observations of students as they engaged in exploratory talk throughout the day. Additionally, student work and photographs were collected to augment research findings.

AUDIO RECORDINGS

The recording of spoken language in the classroom has a rich history in educational research (Lankshear & Knobel, 2004). In particular, teacher researchers have recorded verbal discussions to better understand the role of classroom language and inform practice. Recording talk typically utilizes a recoding device to capture speech related to the research question. The talk can then be transcribed to use for research and analysis. Limitations include the impossibility of collecting all talk that occurs as well as the interference such recording can play with classroom dynamics. Lankshear and Knobel suggest that more sophisticated recording devices can be distracting, maintaining that a small cassette recorder may be less obtrusive. However, researchers must ensure that the quality of the recording will support their research efforts.

In addition, transcribing spoken language into written text involves judgment on the part of the transcriber (Marshall & Rossman, 2006). Visual cues which help interpret the speaker's meaning are not available. Thus, transcribers must use judgment as they create a representation of someone's speech (Lankshear & Knobel, 2004). Attention must be given to ensure that what is included in the transcript is justified by the research question and conceptual framework.

For the purposes of this research, a small digital tape recorder was used. Student talk was recorded during small group work then downloaded onto a password-protected computer. Discourse was transcribed using a software program called Digital Voice Editor 3. This program allowed transcription of the recordings into verbatim transcripts. The transcripts revealed teacher and student interactions during small group problem-solving. Verbatim transcripts provide as much information as possible about the dialogue (Lankshear & Knobel, 2004). Lankshear and Knobel suggest that data collection and analysis should reflect the research question. As I wanted to examine students' exploratory math talk, more information was needed than just the content. This required capturing overlapping talk and speech that is incomplete as this type of discourse is common to exploratory talk (Barnes, 1992). Thus, attention was given to ensure that my transcriptions were justified by my research question and conceptual framework.

During the transcription process, a rough draft of students' speech was created. I then reviewed the draft, making corrections and filling in gaps until an adequate representation of the activity was constructed. Student responses were coded to allow for easy retrieval during analysis and to maintain confidentiality. Coding consisted of identifying the group number followed by the week of the discussion, then sequentially numbering the utterances as they were spoken. An utterance can be defined as a conversational turn which denotes a change of speaker (Baktin, 1986; Lindfors, 1999). It typically is not a complete sentence; rather it is incomplete speech that signifies meaning on behalf of the speaker (Lindfors, 1999). Utterances are not usually grammatically correct and can include mispronunciations, "uh huhs", and other types of irregular speech. All data were stored in a locked file cabinet. At the end of the research study, all the data were removed from the computer to ensure confidentiality and anonymity of data.

While familiar with many types of technology, this research study forced me to step outside my comfort zone. This resulted in a few learning experiences which included a malfunction of the digital tape recorder at the onset of the study. Data from group four's first week taping were lost. I learned to have a set of replacement batteries ready for use. In addition, in transcribing the recordings, a few difficulties arose including: (1) identifying who was talking as some voices sounded very similar on the tape; and (2) capturing speech that was spoken very softly and not picked up by the recorder. Additionally, background noises from other classrooms distorted the quality of the recording at times. Because transcription began immediately after data collection, these problems were addressed early on in the research. For example, students were asked to state their name prior to beginning small group discussions, providing a spoken example to refer to when identifying the speaker. In addition, this identified who was present at the time of the recording. For those students who tended to speak quietly, the recorder was moved to capture their talk. They were also instructed to speak loudly as needed. Finally, data collection in the context of a busy school environment means that noises will occur. To account for this, taping was stopped at times until the hallways were cleared.

VIDEO RECORDINGS

Video recordings can capture important details that cannot be collected using audio recordings (Lankshear & Knobel, 2004). Video-taping students as they talk provides opportunities to witness their gestures and other actions accompanying speech. However, there are limitations. Special ethical considerations must be taken when recording students' faces, ensuring that confidentiality is upheld. In addition, the time needed to transcribe videotapes may be lengthy compared to audio recordings. Video cameras can also affect the classroom environment as participants may change their behavior if they know they are being video-recorded. Lankshear and Knobel recommend carefully preparing the environment such as introducing the device as well as utilizing trial runs prior to data collection. "This helps remove much of the mystery of the camera's presence and, subsequently, much of the students' interest in it being there" (p. 197).

To capture whole group discussions, a digital video camera was displayed on a tripod in the corner of the classroom. It was set to a wide angle lens to capture students engaged in discussion on the classroom carpet. While the majority of students could be viewed, a few places on the carpet were outside the camera's range. These were reserved for students who did not give their assent.

The video camera was in place several days prior to actual taping. I introduced the camera, explaining that it would help me understand what students know about math. The students were typically excited about "being on TV." However, the newness quickly wore off as they became familiar with the research device and we were able to settle into classroom routines.

In the classroom, students sat in assigned places around the edge of the carpet. Students without daily assent to participate were seated on the carpet out of range of the camera. This rarely occurred in the classroom as the majority of students gave their assents to participate. At the onset of the project, I was concerned that students might identify those spots with students who were not involved in the taping. However, student movement on the carpet was common throughout the school day due to misbehaviors or to make room for teaching materials. Often I joined the class on the carpet, occasionally taking a student's place by mistake. The student would then locate an empty spot. Thus, for the purposes of this research, I feel confident that students did not seem to connect a certain spot on the carpet with non-assent.

I manually set the video recorder to tape and began the lesson. After taping, the video recordings were digitally downloaded onto a password-protected computer utilizing the computer software program InqScribe. Inqscribe allows the transcriber to simultaneously view and transcribe video. A foot pedal was used to control the flow of the discourse. During the transcription phase, a time code was inserted periodically into the written record to allow easy retrieval of speech during the analysis stage. In addition, actions that accompanied the classroom discussion were given a separate line in the written record entitled "Activity." Information about the activity was written in a non-judgmental way, refraining from making inferences that might be drawn during the later analysis stage (Lankshear & Knobel, 2004). In my dual role as a teacher/researcher, this required that I visualize the occurrence through a researcher's eyes, attempting to describe rather than attribute meaning to what was happening. Any information that I felt was necessary to accurately understand what was occurring was bracketed to note the role of teacher in viewing the occurrence.

After a transcript was complete, participants' responses were coded by identifying the week and the day that the discussion occurred as well as sequentially numbering the utterances. Responses were removed for students that had not given their daily assent. Video tapes and transcripts were stored in a locked file to ensure confidentiality and anonymity of data. All video recordings and transcripts were removed from the computer at the end of the research study.

During the transcription phase, several problems occurred. The time invested in transcribing the tapes was much lengthier than I had originally planned, at times taking as long as one hour to transcribe ten minutes of video. This was primarily caused by the difficulty in transcribing both speech and action. To account for this, my initial transcription consisted of a rough draft, identifying the speaker as well as a simple sketch of the activity accompanying speech. I later revisited the written record while watching the video, fleshing out any gaps or inconsistencies I had failed to capture and ensuring that I had carefully portrayed the actions that transpired during the discussions.

In addition, as with the audio recordings, it was difficult to understand some students' speech. I found that by enlarging the video screen during transcription, I was able to observe the student's mouth which helped to record speech. Discourse was also replayed at various speeds in an attempt to catch missing words. Finally, if unsure, a question mark was placed next to the speech and revisited at a later date. This strategy allowed me to capture the majority of talk that occurred in the whole group setting.

Another difficulty was overlapping speech. During whole group discussions, I controlled the turn-taking to guide the conversations. However, at times, interruptions occurred. This required that I denote such occurrences in my transcriptions. Thus, the use of a slash (/) stood for overlapping speech that occurred when two or more speakers talked at the same time.

Finally, student misbehaviors played a role in the data collection. Typically, by the time math instruction began, students were worn out from a long active day in Kindergarten. Rather than adjust my teaching schedule to account for this, I wanted to keep the data collection as natural as possible (Lankshear & Knobel, 2004). In my school district, teachers are given times when subjects are to be taught. This required that I maintain the same schedule throughout the year. However, this also meant that misbehaviors occurred and had to be dealt with. At times, recordings were turned off to allow the behavior to be handled in a sensitive manner. However, that is both the beauty and the beast of teacher research. It does not take place in a sterile environment—rather, the classroom is ripe with conflict. However, this adds to the legitimacy of teacher research—understanding the learning which occurs in the midst of messy, chaotic classroom life.

OBSERVATIONS

Observations can be defined as a systematic recording of behaviors and events that occur naturally in the social setting selected for research (Lankshear & Knobel, 2004; Marshall & Rossman, 2006). They can range from highly structured, detailed accounts to more open-ended descriptions. Written records are typically gathered during the observation called fieldnotes (Lankshear & Knobel, 2004). Fieldnotes can be extremely structured such as checklist or they can be a more holistic account of the event. Additionally, post facto notes can be used to record observations that occur after the fact. Researchers must ensure that their observations are descriptive rather than interpretive. Inferences can be drawn later during the analysis stage.

A researcher can hold various stances during the observation including non-participant observations in which the researcher is removed as much as possible from the setting being studied. Lankshear and Knobel (2004) suggest that this can be difficult in education as the very presence of a researcher impacts the context under study. Researchers can also be full participants in the observations, engaging directly with what is being observed (Marshall & Rossman, 2006). Teacher researchers have a marked advantage in engaging in full participant observations as they are already established members of the classroom (Lankshear & Knobel, 2004). Their insider perspective lends credence to their data interpretations. However, such status can lead to research bias. Teacher researchers must carefully document their observations to ensure that their observations are judgment-free. Researchers can also engage in peripheral participation which involves a mix of full participation, partial participation, and non-participation based on the event being studied.

For the purposes of this research, I conducted five observations throughout the research project, noting any occurrence of exploratory talk. Observations were gathered and recorded in a teacher research journal. Specifically, I observed students during times in the classroom when my participation was less involved, allowing me to engage in peripheral participation. For example, several students were in charge of setting up the calendar and taking attendance at the beginning of the day. Copley (2000) suggests that classroom routines are ripe for problem-solving and discussion. I was able to observe unobtrusively while still overseeing the classroom. I quickly recorded information about the participants as well as the activity along with examples of their speech. At a later time, I revisited the observations, replacing student names with their first initial to preserve confidentiality. Other observations were more open-ended and occurred during whole-group discussion time. For example, as a classroom practice, we engaged in classroom meetings where problems were discussed in a sensitive manner. The goal was not to place blame but to discuss possible strategies to help our classroom. My stance as an active member of the discussions eliminated the possibility of writing detailed observations at the time. However, I was able to record observations at a later time using post facto notes (Lankshear & Knobel, 2004).

The observations did not provide a large amount of data. However, they did provide a "slice of classroom life" (Cohen, Manion & Morrison, 2000, p. 21) that demonstrated the role exploratory talk can play as problems occur throughout the day. The discourse resulting from the observations was then transcribed and coded with the number of the observation followed by numerical ordering of the utterances. In addition, information about the activity in which the discourse was observed was recorded to provide contextual understanding (Lankshear & Knobel, 2004).

Additionally, a teacher research journal can provide insight into the research process. Herr and Anderson (2005) believe that due to the complexity of teacher research, a research journal is a crucial piece of methodology. “It is a chronicle of research decisions; a record of one’s own thoughts, feelings, and impressions; as well as a document reflecting the increased understanding” (p. 77) that comes with the research process. Furthermore, a journal allows the researcher to keep track of ethical decisions made throughout the research study.

Throughout the research phase, my teacher research journal quickly became a repository where I recorded student observations as well as the conflicting emotions that arose in the research process. Anxiety, fear, exhaustion, exhilaration—all were recorded to allow later reflection on the experience. In addition, during the analysis stage, the journal became an outlet for my continual refinement of both the questions and the emerging answers.

DATA ANALYSIS AND SYNTHESIS

Qualitative analysis brings meaning to the data (Bloomberg & Volpe, 2008). Formal measures typically include managing the data, coding, and interpretation. In positivist research stances, analysis generally occurs after data collection (Lankshear & Knobel, 2004). However, qualitative analysis is highly intuitive and non-linear; thus, it should occur simultaneously with data collection (Bloomberg & Volpe, 2008; Merriam, 1998). For the purposes of this research, an informal analysis was ongoing due to the participatory nature of the study as well as immersion into the data during the transcription process. As a teacher researcher, I hold a unique stance in the classroom—one of researcher, guided by theory combined with that of a seasoned teacher, experienced in the world of the classroom (Cochran-Smith & Lytle, 1993). As I observed my students throughout the collection process and during transcription procedures, this dual lens was activated, allowing me to view how the teacher and learners construct knowledge together. These understandings impacted the development of my conceptual framework as well as subsequent data collection.

Data collection methods resulted in a large volume of data including seventeen video tapes, forty audio recordings, and a teacher research journal totaling over five hundred pages of classroom discourse. The challenge was to make sense of the information, utilizing my conceptual framework to guide emerging patterns. The formal process began by color-coding the discourse into three preset categories to determine if it was presentational, exploratory, or other types of talk (Barnes, 1992; Mercer, 1995). Table 3.3 presents the initial coding schema.

Table 3.3 Initial Discourse Coding

Presentational (yellow)	Exploratory (blue)	Other (orange)
• Approved answer • Convergent and/or factual responses • Instructions given or regiven • Procedural questions or statements • Student or teacher giving information	• Sharing of ideas • Active but constructive engagement with others' ideas • Statements and suggestions are offered for joint consideration • Requests for explanations and clarity • Ideas may be challenged but are justified • Alternative theories presented • Joint agreement in decision making • Reasoning is visible in the talk	• Brief exchanges • Disagreements that are not constructive or supported • Repetition of ideas • Uncritical agreement • No evidence of reasoning • Confirmations • Elaborations • Initiations accepted without discussion • Superficial agreements • Other types of talk

While this framework identified examples of exploratory talk, the remaining discourse proved difficult to code as it did not always fall into the remaining two categories. Additionally, I realized that this coding scheme was too shallow and did not provide the level of insight necessary to fully understand the topic. A revised conceptual framework was developed based on the literature review as well as intuitive understandings drawn from my ongoing analysis. Each category was directly tied to one of the study's five research questions. Descriptors were added under each category. Categories were purposely left open-ended to allow the data to drive the further refinement of the framework (Bloomberg & Volpe, 2008). Table 3.4 details the conceptual framework at the beginning of the analysis stage.

Table 3.4 Initial Conceptual Framework

Mathematical understanding
Number and operations Algebra Geometry Measurement Data analysis
Sounds like
Pauses Um Repetition Other
When does it occur
Whole group Small group Other times
Support
Teacher Peer
Social Norms
Builds on others' talk Misunderstandings Conflict Explanations Joint agreement Other

I recorded categories and descriptors from the conceptual framework onto large sheets of chart paper and displayed these on the wall. The writing on each sheet was color-coded to allow for easy retrieval. As new themes emerged, additional sheets were added. The discourse was then examined and assigned alphanumeric codes, linking it to a category and descriptor on the conceptual framework using categorical analysis (Lankshear & Knobel, 2004). Categorical analysis is the "process of developing and applying codes to data" (p. 271). It is a continual process that examines the relationships that emerge based on the research question and supporting theory. Discourse that did not fit into a category was placed in a miscellaneous category. Appendix F presents the coding schema used during the final analysis stage. Appendix G displays an example of coded discourse.

After coding, the data were cut apart into individual utterances and affixed to the appropriate charts using repositional glue. Key words or phrases were highlighted that supported the placement, such as the word “um” or an example of a probing question. A complete copy of each coded lesson was stored. However, the charts quickly became the driving mechanism for analysis as utterances were repositioned as patterns emerged. Findings were then tallied on Data Summary Tables (see Appendixes H-N) that presents data on individual participants as well as the overall class, lending credence to my audit trail (Bloomberg & Volpe, 2008). Tallies were marked using different colors of writing utensils (i.e., red for small group, pencil for whole group, black for other) to allow the findings to emerge across data types.

New themes emerged quickly, leading to the continual refinement of the coding scheme. Some patterns were inherent in the participant discourse, such as specific examples of irregular speech and teacher talk. Appendix O details the development of the coding framework. Additionally, analytic memos were recorded on color-coded post-it notes and affixed next to the corresponding charts (Marshall & Rossman, 2006). These contained unique insights into the data in an effort to “move the analysis from the mundane and obvious to the creative” (p. 161). Finally, I utilized an additional chart which contained discourse that I found unusual or especially insightful.

After all utterances were coded and assigned, I reexamined each coded lesson to identify any overlooked data and verify the coding using the final version of the conceptual framework. Any changes were recorded on the Data Summary Tables and adhered to the charts.

Throughout the process, I found myself continually questioning what exactly was exploratory talk. My evolving definition began with my initial readings on the topic followed by my attempts to facilitate and capture such talk in my own classroom. Later, through analysis of my three data sources, the refining continued. This progression led to an interesting revelation that arose during the final analysis stage. In examining one of my research questions, “What does exploratory talk sound like in Kindergarten students?”, I realized that my findings thus far emphasized only the irregular speech patterns. However, the actual utterances revealed much more.

I returned to my initial coding scheme, using it to loosely frame the students’ exploratory talk while, at the same time, allowing the actual utterances to drive the refinement. I then began to group the utterances based on what was emerging in the talk. As I worked, the utterances became pieces of a puzzle—apart, they didn’t portray the meaning that arose when viewing them contextually. Thus, the analysis process changed from gathering bits of data to synthesis—looking at the holistic picture to gain understanding of the phenomena.

However, this process of continual refinement resulted in a few inconsistencies which were revealed on the Data Summary Tables. To aid with organization, I created a set of index cards for each participant. I reexamined each lesson, sifting through utterances to locate exploratory talk. Any examples were listed on an index card indicating the week and where the talk occurred (either in whole group, small group, or other times of the day) along with what was revealed in the talk using the revised

Conceptual Framework. This system allowed me to track the actual number of occurrences, ensuring that my Data Summary Tables accurately reflected my findings. Additionally, I noted the mathematical concepts that were present in the exploratory talk.

Finally, I examined the charts and Data Summary Tables, noting the patterns that emerged across data sources. These patterns became the research findings. In addition, I recorded each finding on a Consistency Chart which provided a template for later analysis and conclusions (see Appendix P).

ETHICAL CONSIDERATIONS

Researchers must ensure that all study participants are not harmed as a result of the research (Lankshear & Knobel, 2004). Ethical considerations must be taken to safeguard the well-being of those under study. This includes adhering to formal ethical codes and procedures supervised by the Institutional Review Board [IRB]. In addition, teacher researchers have increased responsibility for the children in their care because of the dual role of the teacher as researcher. Lankshear and Knobel suggest that certain criteria be met when investigating one's own classroom. These include establishing a valid research design, avoiding deception, minimizing intrusion, ensuring confidentiality, demonstrating respect, and avoiding coercion (p. 103). Each of these principles will be discussed in detail and related to the current research study in the next section.

IRB Approval

Prior to beginning the study, approval was sought from the Oklahoma State University's IRB. Research was conducted in accordance with the research design, but subject to change based upon ongoing formative analysis of data. District administration, the building principal, research participants, and their parents or guardians were informed of the intent of the study as well as how research procedures and confidentiality would be maintained. Signed consent forms were collected from parents. Verbal consents were gathered from the students participating in the research each time data were collected.

Valid Research Design

A strong research design demonstrates the overall competence of the researcher in completing the study effectively (Lankshear & Knobel, 2004; Marshall & Rossman, 2006). It can be viewed as a form of logic—"as the shape of an argument which starts with a question, organizes a response, mobilizes evidence, justifies points that are made and derives a conclusion which "follows from" the previous steps" (Lankshear & Knobel, 2004, p. 30). A conceptual framework framed the current study within an existing body of theory and knowledge on exploratory math talk. Research questions, methods, and data analysis all flowed from the initial design, thus increasing the validity of the research.

Avoidance of Deception

Research participants must be fully informed of the research purpose. This requires that they are not given false information. With young children in particular, parents need to understand research procedures as deception can seriously harm the trusting relationship between the teacher and the families in the classroom (Lankshear & Knobel, 2004; Stremmel, 2007). Acquiring informed consent and providing clear information about the research process are vital to avoiding deception. Throughout this study, I took seriously my role as a teacher, including my responsibility to my students. I took every measure to ensure that I was not deceptive during any phase of the study. I talked personally with each family to make certain that they understood the research study. Utilizing a script ensured that families received the same information. The research study was also discussed with my students. Additionally, I gathered assents each time data were collected. At the end of the study, I spoke with each family, thanking them for allowing their child to participate. These principles helped maintain the trusting relationship that was established in the classroom prior to the start of the research study.

Minimize Intrusion

To minimize intrusion, a teacher researcher should avoid impositions that do not contribute to the research topic (Lankshear & Knobel, 2004). Recognizing that all research has an impact on the social dynamics of the classroom, I attempted to minimize intrusion by maintaining the classroom routines that had been implemented since the beginning of school. In addition, math instruction was not significantly altered as students had been exposed to both whole- and small-group math activities as well as math discussions.

Ensure Confidentiality

Participants should feel confident that their identities will not be revealed in any written report. This was reported in writing to the parents in the parental permission form. As I was committed to ensuring that student names and other characteristics were kept confidential, cautionary measures were taken. In all written reports, student pseudonyms were used. Coding sheets and original documents were securely stored offsite in a locked file cabinet. In addition, I was the only one who had access to the materials.

Demonstrate Respect

An atmosphere of respect is essential to teacher research (Lankshear & Knobel, 2004). In such an environment, students feel comfortable answering honestly without fear of reprisal. Involving students in evaluating the research study can enhance the results as well. For the purposes of this research, students gave their assent each time data were collected. This allowed students to have control over their participation throughout the research study. On the last day of data collection, I met with the students to discuss the project. Students shared what they had learned, providing insight into the role of research in the classroom. These practices helped foster a respectful relationship between myself and the students.

Avoid Coercion

Teacher researchers need to be cognizant of the unequal relationships between the students and the teacher (Lankshear & Knobel, 2004). This required that I pay close attention to power relationships throughout the study. In particular, when gathering student assents, I utilized a friendly, conversational tone when reading the assent script to eliminate feelings of coercion to participate in the research that day. While the majority of students gave their assent, a few did not. I had to ensure that they did not feel forced to participate through my words and actions. This affirmed their opportunity to choose for themselves.

ISSUES OF TRUSTWORTHINESS

While qualitative approaches are more readily accepted in the research community, the criteria for judging the soundness of such inquiry remains under debate (Marshall & Rossman, 2006). This requires that qualitative researchers establish the trustworthiness of a study. Lincoln and Guba (1985) propose four terms that acknowledge the inherent differences in qualitative research yet make connections with the more readily accepted positivist criteria. These terms are credibility, transferability, dependability, and confirmability (p. 43). Application of such terms to establish trustworthiness for the current research study will be discussed in the following sections.

Credibility

Credibility examines how well the research findings match or represent the reality under study (Lincoln & Guba, 1985; Merriam, 1998). Comparable to internal validity in positivist research, qualitative researchers, however, recognize that reality is constructed by individuals (Lankshear & Knobel, 2004). Such a criterion for qualitative research examines the internal measures that demonstrate soundness of the argument as well as evidence used to support these claims. Various strategies can be taken to strengthen a study's credibility. These include long-term observation of the phenomenon, utilizing multiple sources of data (triangulation), as well as making use of peer debriefings (Bloomberg & Volpe, 2008). Additionally, as with any research, the results are limited by the integrity of the investigator who serves as the primary instrument for data collection and analysis (Merriam, 1998). Thus, identification of research bias is necessary to promote credibility.

This research study took place during a school semester, allowing for prolonged engagement and systematic inquiry into the research topic. Triangulation was met through the various methods of data collection, including video tapes, audio tapes, and student observations. In addition, I made use of peer debriefing to ensure the accuracy of my account of the research findings (Merriam, 1998). A professional colleague who had an understanding of the research study was asked to provide insight and comment on the results as they emerged. This enabled me to utilize different perspectives in examining the findings resulting from the data.

Acknowledgment of my research bias was also necessitated. As an early childhood educator, I believe young children enter my classroom with a wide variance in mathematical understandings. While children's knowledge may be primitive, it is up to the educator to build connections between a child's mathematical beginnings and more formalized mathematics instruction. Based on my experiences, I have found that young children may have a much stronger understanding of mathematics than typical assessments may reveal. As my experiences and beliefs have precipitated an interest in the topic of study, every measure was taken to enhance the objectivity and trustworthiness of the study which included recording reflective notes in my teacher research journal throughout the research process.

Transferability

The criterion of transferability is similar to external validity in quantitative research which measures how well the findings can be generalized to another setting (Lankshear & Knobel, 2004; Lincoln & Guba, 1985; Marshall & Rossman, 2006). While qualitative research is not meant to be generalized, lessons learned from the research can be transferred to another setting (Lincoln & Guba, 1985). This requires a thick, descriptive narrative that "gives the discussion an element of shared or vicarious experience" (Bloomberg & Volpe, 2008, p. 78).

While realizing that this research only provides a glimpse into the world of a select group of students, the descriptive nature of the project will allow readers to evaluate the application of the research to their own setting.

Dependability

Reliability in the quantitative sense refers to how well the research results can be replicated (Bloomberg & Volpe, 2008). In qualitative research, however, it is understood that reality is not constant (Marshall & Rossman, 2006). Thus, dependability refers to how the researcher handles the changing conditions in the phenomenon under study, resulting in an increasingly refined understanding. Such undertakings require an audit trail that provides a detailed account of how data were collected and analyzed thus determining if results are consistent with the data (Merriam, 1998).

Throughout this project, I have documented the procedures for data collection as well as how categories were formed for analysis. This information was recorded in my teacher research journal as well as in supporting documentation that included detailed accounts of data collection methods and analysis. Raw data (documents, student work, transcripts, observations) and data analysis products are stored to allow others to confirm the accuracy of the research. Additionally, audio and video tapes are available for review.

Confirmability

Confirmability corresponds to objectivity in quantitative research (Lincoln & Guba, 1985). This implies that the findings result from the data, not the subjectivity of the researcher. However, qualitative research acknowledges research subjectivity (Merriam, 1998). By providing an audit trail as well as identifying any pre-existing biases, the researcher is able to demonstrate how the findings emerged from the data. Additionally, Lincoln and Guba suggest that the logic of the research study be made apparent, thus strengthening the results.

While acknowledging the subjective nature of qualitative research, procedures were put in place to ensure the study's trustworthiness, including documentation of the audit trail as well as identification of researcher bias.

CHAPTER SUMMARY

This chapter provides a detailed account of the study's research methodology. Qualitative teacher research methodology was utilized to understand what is revealed in Kindergarten students' exploratory math talk and the social context affecting the study. Twenty-two students in my Kindergarten class were involved in the study. Three data collection methods were employed, including audio recordings, video recordings, and observations. After transcription, the resulting data were analyzed using an evolving coding system drawn from the study's conceptual framework. Trustworthiness and ethical considerations were taken throughout the study to maintain the integrity of the research project.

CHAPTER IV

FINDINGS

INTRODUCTION

The purpose of this study was to examine what is revealed in Kindergarten students' exploratory math talk. I believed that through such examination, insight could be gained into understanding children's mathematical knowledge. In addition, the classroom discourse was examined to understand the social context affecting the study. This chapter presents the findings obtained from a twelve-week research study into my own classroom. Seven major findings emerged from the study and include:

1. A large amount of exploratory talk was related to mathematical concepts. Number and operations were found in the majority of the mathematical utterances. Talk related to measurement was also found in some mathematical exploratory talk followed by data analysis. Geometry and algebra represented a small amount of exploratory math talk. A small number of errors were identified in which students shared incorrect responses. Exploratory talk related to number and operations had the largest amount of errors followed by measurement, data analysis, and geometry.
2. The overwhelming majority of participants had speech disfluencies in their exploratory talk. Most participants used "um", had pauses, abbreviations, and

repetition in their talk. Some participants used “like” and “uh”. A few participants had false starts and overlapping speech.

3. All 21 participants shared their ideas using exploratory talk. The overwhelming majority of participants offered statements for joint consideration. The majority of students challenged others’ ideas, set up hypotheses, gave requests for clarity, and had joint agreements in their talk. Some used evidence, drew conclusions, provided alternate theories, and revised their thinking.
4. The majority of students used their hands and fingers as they engaged in exploratory talk. Many participants used gestures, including pointing. A few participants gestured as they dramatized part of their response. In addition, some students used their fingers to solve problems.
5. A large amount of exploratory talk utterances were found which occurred during small group activities, whole group lessons, and observations. All 21 participants engaged in exploratory talk during small group and whole group activities. A small number of students had examples of exploratory talk during observations, including calendar, math activities, snack preparation, and a class meeting.
6. Much of the teacher support was the use of reply not assess words. Some of the teacher support included the revoice of students’ responses and the use of open-ended questions. A small amount of teacher support included review, the teacher acting as a peer, leading students through their puzzlement, informal use of math vocabulary, and the use of tools to support thinking.
7. The majority of social norms found in the classroom discourse emphasized shared decision-making. Some of the norms were related to sharing ideas. A small

amount of the class norms referred to problems. A few reflected old norms and conflict.

Each finding will be discussed in rich detail to allow readers to enter into the research, evaluating a possible application of the findings to their own settings. Throughout the chapter, illustrative discourse drawn from whole-group, small-group, and observational data will be presented, enabling participants to share their perspectives.

Finding 1: A large amount of exploratory talk was related to mathematics (745 [51%]). Number and operations represented the majority of math-related exploratory talk (445 [60%]) followed by measurement (139 [19%]) and data analysis (107 [14%]). Geometry (44 [6%] and algebra (9 [1%]) represented a small amount of exploratory math talk. A small amount of errors were found in which students shared incorrect responses (64 [9%]) . Exploratory talk related to number and operations had the largest amount of errors (34 [53%] followed by measurement (20 [31%]), data analysis (5 [8%]), and geometry (5 [8%]).

A central finding of this research study is that a large amount of exploratory talk was about mathematical concepts (745 [51%]). Number and operations represented the majority of math-related exploratory talk (445 [60%]) followed by measurement (139 [19%]) and data analysis (107 [14%]). A small amount of exploratory math talk was related to geometry (44 [6%]) and algebra (9 [1%]). A small number of errors were identified (64 [9%]), with many of the errors found in talk related to number and operations (34 [53%]). Table 4.1 displays the results of the data analysis. Please note that the percentage given for math-related exploratory talk (51%) refers to the total number of exploratory talk utterances drawn from Appendix L (1473).

Table 4.1 Mathematical Concepts

Descriptor	Total # of utterances	Total # of errors	Participants	Participants with errors
Math-Related Exploratory Talk	**745 [51%]**	**64 [9%]**	**21 [100%]**	**18 [86%]**
Number and operations:	445 [60%]	34 [53%]	21 [100%]	17 [81%]
Object counting	235 [53%]	14 [41%]	21 [100%]	9 [43%]
Verbal counting	113 [25%]	1 [3%]	18 [86%]	1 [5%]
Add/take away	76 [17%]	19 [56%]	18 [86%]	13 [62%]
Compare numbers	18 [4%]	0 [0%]	9 [43%]	0 [0%]
Compose/decompose	2 [1%]	0 [0%]	2 [10%]	0 [0%]
Subitizing	1 [≥ 1%]	0 [0%]	1 [5%]	0 [0%]
Measurement:	139 [19%]	20 [31%]	17 [81%]	10 [48%]
Attributes, units, processes	91[65%]	16 [80%]	16 [77%]	7 [33%]
Techniques and tools	48 [35%]	4 [20%]	15 [71%]	4 [19%]
Data Analysis:	107 [14%]	5 [8%]	19 [90%]	4 [19%]
Representation	57 [53%]	0 [0%]	17 [81%]	0 [0%]
Classification	50 [47%]	5 [100%]	16 [76%]	4 [19%]
Geometry:	44 [6%]	5 [8%]	16 [76%]	4 [19%]
Shapes	25 [57%]	1 [20%]	9 [43%]	1 [5%]
Spatial awareness/location	18 [41%]	4 [80%]	13 [62%]	3 [14%]
Putting together shapes	1 [2%]	0 [0%]	1 [5%]	0 [0%]
Transformation and symmetry	0 [0%]	0 [0%]	0 [0%]	0 [0%]
Algebra	9 [1%]	0 [0%]	5 [24%]	0 [0%]
Repeating pattern	9 [100%]	0 [0%]	5 [24%]	0 [0%]
Growing pattern	0 [0%]	0 [0%]	0 [0%]	0 [0%]

Number and Operations

An understanding of numerical concepts includes two interrelated domains: (1) number; and (2) operations (Clements, 2004). Sarama and Clements (2006) identify six main mathematical topics for number, including: verbal counting, object counting, subitizing, comparing numbers, adding and subtracting, and compose/decompose numbers. Number and operation represented the largest amount of math-related exploratory talk (445 [60%]). All 21 participants had examples of number and operations in their talk (100%). Exploratory talk related to number and operations had the largest amount of errors (34 [53%]), including adding and taking away (19 [56%]) and object counting (14 [41%]).

Object Counting

Object counting in which students create a one-to-one correspondence between a number and an object represented over half of the numerical utterances (235 [53%]). All students had examples of object counting in their talk (100%). These included participants using counting as a strategy to solve problems (19 [90%]). After a student posed the question, “Is a spider an insect?”, students compared a spider to a beetle. Alvin stated, “I got 8 legs!” as he examined a plastic spider using a magnifying glass. Other students counted a set of objects together:

Aaron: I think there’s 20!

1, 2, 3, 4, 5, . . . 13, 14 we have 14

15, right—we have 15, right?

Chris: 16 right here

Aaron: 17 right here, 18 right here, 19 right here, 20 right here because you got one there

The majority of participants talked about object counting as they shared ideas to solve problems (17 [81%]). During a small group activity, students identified how to determine the total number of chairs needed for a classroom party. Megan said, "I can count how much people are in the classroom" while Kara voiced, "You could count the artwork that we have." Other small groups thought of different ways. Stacey suggested, "Um we can go around counting all the chairs" while Mia added, "Well um write write h-- how many chairs they are." After Colby shared her idea of counting people, Chris stated, "Um, (pause), maybe we can use Colby and we can put some cubes um on chairs and you would count the cubes. We can put the cubes on the paper and then we can write the number."

Some errors with object counting were identified (14 [41%]). After identifying there were 22 people in the classroom that day, students were challenged to identify what else they had 22 of. Alex suggested, "Twenty-two (pause) 22 hands." After noting that Ivan had seven counters laid out at the top of a sheet of paper, the teacher asked how many counters he had. Ivan stated, "Five." While working with a small group, Justin counted a set of 10 objects, stating, "1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11." When asked if the group agreed with his total, Steven recounted, identifying that there were 10.

<u>Verbal Counting</u>

Verbal counting consists of learning the sequence of number words (Sarama & Clements, 2006b). Some of the exploratory math talk was related to verbal counting (113 [25%]. The majority of participants used verbal counting as they counted objects (18

[86%]). While solving a problem during a whole group activity, Madison stated, "1, 2, 3, 4, 5, 6, 7, 8, 9, 10." Aaron suggested counting a group of objects by twos, stating, "So we can do this: 2, 4, 6."

One participant had an error with verbal counting (1 [5%]). Justin counted, "14 16" while counting out 21 objects to represent the total number of students in the classroom.

<u>Add/Take Away</u>

Adding and taking away requires an understanding that sets can be made larger or smaller by the addition or removal of objects (Clements, 2004). Talk related to adding and taking away was found in some of the exploratory math talk (76 [17%]). Some of the students referred to the concept in their math talk (18 [86%]). During a whole group activity, students shared ideas on how to figure out the number of counters needed to make 10:

> Um, we can um add more cubes to um the to those cubes (points to four cubes in the middle of the carpet) and um then you can add um more cubes and you make um that those cubes um to 10. (Megan)

Adriana suggested, "Add two" after identifying that her group had 18 legs and needed 20. Steven voiced, "Ten!" during a whole group activity in which two counters were added to a set of eight.

Counting on was a strategy demonstrated by some of the students (4 [24%]). Counting on can be defined as a shortened counting procedure where instead of beginning the count at "one", the student counts on from the last number (Sarama & Clements, 2006b). One participant, Madison, counted, "7 8!" as her group added two more to a set of six. Kara demonstrated how she used counting on to solve a problem: "Because I um I these were all stuck together. I counted to seven, I'm like 7 (pointing to the last cube), 8, 9, 10."

However, a few participants had difficulty with the concept (2 [10%]) accounting for some of the errors identified (19 [56%]). During a whole group problem-solving activity, Aaron displayed three fingers and replied "8, 9, 10" while counting on from eight to ten. Steven identified "4" as the answer to the problem: I started with ten. There are seven left over. How many are in the mystery bag? When asked to explain his strategy, he stated, "'Cause I counted with my fingers (showed four fingers, one at a time) 7, 8, 9, 10."

A few participants utilized counting to solve addition and subtraction problems (3 [14%]). After predicting there were two pigs in the barn, Kara explained, "Because um there um if there's only two tails (displays one finger on each hand) and um if there's only two tails that means that there's two pigs." Another student used counting to figure out how many cookies were eaten:

> I counted to 20 and then and then I counted to 20 again and then I counted 1 and then (pause) I came up. And yesterday I counted to 20 and counted to 20 and that makes 40 and I counted one more and added up to make 41. (Chris)

Other participants discussed using adding and taking away as a strategy to solve problems (3 [14%]). During one activity, students were asked to figure out how many students were in the classroom. Chris suggested looking at the attendance stick which is a row of cubes snapped together that stood for the number of students in the classroom.

He stated, "Uuuum, if someone is gone and there's more than that people you can just look at the cubes and take one of them."

Compare Numbers

To compare numbers means an understanding that two or more groups can be compared using terms such as *more, less*, or the *same* (Sarama & Clements, 2006b). The findings reveal that a small amount of utterances referred to comparing numbers (18 [4%]). Some of the participants used number comparison in their exploratory talk (9 [43%]). After voting to see which was the favorite food in the classroom, Alvin stated, that Michael's idea, pizza, was the winner "because he has the biggest number." Chris predicted that the bear would weigh less than the elephant, stating, "Yes all right the bear's 100-the elephant is 1,000!" No errors with number comparison were found (0%).

Compose/Decompose

To compose and decompose numbers means an understanding that a whole consists of parts which can be taken apart or put together (Sarama & Clements, 2006b). Several participants demonstrated the concept (2 [10%]. During a whole group lesson, students identified ways to share a box of cookies. Jamie suggested, "If you uh uh got too much and people have zero, uh uh you could uh give them one of yours." When asked to further explain his idea if he had two cookies and his friend had zero, he stated, "I would give her one." Findings did not reveal any errors related to composing and decomposing number (0).

Subitizing

To subitize number means to recognize without counting how many objects are in a group (Sarama & Clements, 2006b). One participant demonstrated the concept (1

[5%]). Kara explained her answer, stating, "Because (pause) there's 6 and 4 right there (points to second group of cubes)." There was no errors related to subitizing number (0).

Measurement

An understanding of measurement involves specifying how much of an attribute an object has, such as weight or length (Clements, 2004). Measurement concepts were found in a small amount of the exploratory math talk (139 [19%]). Many of the participants referred to measurement in their talk (17 [81%]). The majority of participants discussed using measurement to solve problems (15 [71%]). Some errors were made related to measurement (20 [31%]).

Attributes, Units, and Processes

Attributes, units, and processes refers to an understanding of measurement which can include giving a number to an attribute such as length or width (Clements, 2004). It can also involve comparison of an object using other objects. A large amount of measurement-related talk involved attributes, units, and processes (91[65%]). The majority of participants had talk related to attributes, units, and processes (16 [77%]. During a whole group activity, a measurement mystery was introduced:

> *Max, Kristina, and Javier were measuring objects in the classroom. These are their results:*
>
> *Max's object = 5 rulers*
>
> *Javier's object = 10 large paper clips*
>
> *Kristina's object = 15 Unifix cubes*
>
> *Who had the longest item? Why?*

After Madison suggested that Kristina's object was the longest, Alex challenged her answer, explaining that Kristina's object was not the longest "cause it's too smaaalll!" Chris agreed, identifying Max's object as the longest. He stated, "Why is that—but it's the longest thing." Steven said, "I think Chris is right." When asked to explain, he moved to the center of the carpet, placing a paper clip at one end of the ruler, stating "because when I measured these, this is right down here. " He continued, "yeah and this is right here" as he placed a cube against the end of the ruler.

Some students attributed a number to an object (5 [24%]). While attempting to identify the mystery object in the classroom, participants lined up cubes along a piece of yarn that was the length of the mystery object. Later, Kristina shared, "Mine was 79 and I thought it was the desk." Other students used numbers to compare the weight of animals as they ordered them from lightest to heaviest:

PR: Okay well what about that animal?

Chris: Um the bear's like 100 pounds.

PR: And where should the elephant be?

Chris: Last because it's 1,000 pounds

Measurement processes had the majority of measurement-related errors (16 [80%]). In the "Measurement Mystery" introduced earlier, Madison predicted that Kristina's object was the longest, stating, "um it—because Javier had 10 and Kristina's was bigger than that—she had more." During a small group activity, students predicted which geometric shape would hold the most. Kristina disagreed with Javier's prediction of the cube. She held up a rectangular prism, stating, "Cause this one it's like longer and taller." Javier suggested, "Well you were pushing yours up." As the argument continued, Steven countered, "um, we—'cause Kristina was running it a little up more so it was like this." When asked how they could find out for sure, he suggested, "Put them down like this."

A few students self-corrected their errors (2 [10%]). In one example, Kara agreed with Madison's response that Kristina would have the longest object, stating, "I think she's right." Later on in the lesson, the students were asked to vote on who had the longest object. Kara put her hand down after initially raising it. When asked why, she explained, "Because um Kristina because if we stick those four rulers (shows 4 fingers) to one, we'll make one longer than that" while pointing to fifteen Unifix cubes.

A few participants shared ideas to solve problems that involved attributes and processes (2 [10%]). During a small group activity, Kristina and Javier argued over which object would hold the most. Kristina stated, "(pause) 'cause if you measure it um you'll probably know the answer."

<u>Techniques and Tools</u>

Measurement requires the use of techniques to compare and measure objects (Clements, 2004). These can include understanding of iteration of a unit which means the repetition of a single unit. It can also include knowledge of how to use various tools such as rulers or scales. An examination of the findings revealed that some of the measurement-related exploratory talk was related to techniques and tools (48 [35%]) by some students (15 [71%]). When asked how to measure the length of a piece of yarn, Steven suggested, "Um we could just um do this" as he moved to a tub of Unifix cubes and began to place the cubes next to the yarn. When asked why he moved part of the yarn that was folded over, he replied, "'cause you have to start at the beginning." During another activity, Aaron shared, "Um you can make them all in a line" as he began placing paper clips in a line, each end of the clip touching the previous one.

Some participants shared ideas for problem-solving that involved measurement tools and techniques (14 [67%]). During a whole group activity, students were asked to predict which object was the odd one out: a ruler, a measuring tape, or a scale. After several students identified the scale as the odd one out, Alex challenged the others' answers, suggesting that a scale can be used to measure. He stated, "We can put like measure toys or stuff like that." Chris suggested that the ruler and measuring tape were alike, stating, "because um this one has like a measuring thing (goes to middle of carpet & pulled out the tape on measuring tape) and this one matches (picked up ruler and placed it next to the measuring tape) because it has a measurement thing."

A few errors related to measurement techniques occurred (4 [20%]. During a whole group activity, Kara suggested that the scale was not used for measurement, stating, "because them two measure and that one doesn't" as she pointed to a ruler and a measuring tape. Chris agreed, adding, "yes because it's on the playground." Mia had difficulty identifying which side of the scale indicated the heaviest, pointing to the side that was in the air, stating, "This side" when asked to identify which bag held the most.

Data Analysis

Data analysis involves organizing and representing information (Clements, 2004). Data analysis contains two topics, namely classification and representation (Sarama & Clements, 2006b). Data analysis represented a small amount of the exploratory math talk (107 [14%]). The majority of students referred to data analysis in their talk (19 [90%]). A small number of errors were found (5 [8%]).

Representation

When learners engage in representation, they are sharing what they have learned which may be in the form of a chart or a graph (Clements, 2004). Some of the data analysis talk involved representation (57 [53%] which was found in the majority of participants' exploratory utterances (17 [81%]. During one activity, students worked with a partner to discuss if a centipede, a caterpillar, and a scorpion were insects before bringing their results to the group for consensus. Jamie and Kara were working together at a table. On their paper, they had circled the world 'yes' for caterpillar. When asked to explain their thinking, Jamie stated, "Um we think caterpillar is." Kara added, "because it changes into a butterfly." During a small group activity, students were asked to show the number of students present in the classroom that day. After sharing his idea of drawing "choo choo trains like Thomas", Steven drew twenty-one blue trains on paper.

Other participants shared ideas to solve classroom problems involving representation (13 [62%]). During a whole group activity, students identified ways to determine the most popular food in the classroom to take on an upcoming field trip. Megan voiced, "We um we can grab a piece of—a square paper and write down our favorite food and then see what stacks the highest." Another day, there was a concern that some students were getting more turns than others. The class was asked to think of ways to identify when a student had had a turn. Alvin suggested, "Do do uh do like if your stick's in the yes cup that means that we did have a turn. Then when we put it in the no cup, uh we all just um see people that didn't have a turn."

No errors related to representation were found (0%).

Classification

Classification means that objects can be grouped or sorted based on certain attributes (Sarama & Clements, 2006b). The objects can be then counted or quantified. There were some utterances related to classification (50 [47%]) found in the majority of participants' exploratory talk (16 [76%]). During an activity when students compared a spider to a beetle, Javier noted, "The beetle had antennas and the spider didn't." Chris stated, "Um that your um—um spider has 8 legs and the beetle has 6 legs." During a small group activity where students had to order animals from the lightest to the heaviest, Justin challenged another student's answer, stating, "No the mouse—this goes with that one and then this one goes with that one! So—these are the little ones and these are the big ones."

A small number of errors were identified related to classification (5 [100%]). During a small group activity, students had to order pictures of zoo animals from lightest to heaviest to prepare them for feeding. Alvin placed the mouse picture after the elephant picture, stating, "No it weighs more than the elephant cause elephants are big! But not these little teeny mouse cause they look tiny." A few group members corrected each other (2 [10%]):

PR:	Okay where should the duck go?
	Do you guys agree that it goes mouse, monkey, duck? . . .
PR:	Oh why do you say you disagree Alex?
Alex:	'Cause this is heaviest one
PR:	You think a duck is heavy?
Alex:	Yeah
PR:	Do you guys agree? Talk to them about it. Tell them why.

Adriana: Because um tigers weigh more.

PR: Tigers weigh more Adriana says. Do you guys agree?

Students: Yes.

No participants discussed classification as part of a problem-solving idea (0%).

Geometry

Geometry involves geometric and spatial reasoning which can include shape recognition, putting together shapes, transformation and symmetry, and spatial orientation (Clements, 2004). A small amount of talk related to geometry was found (44 [6%]) for the majority of participants (16 [76%]). There were a few errors made (5 [8%]).

Shapes

Understanding of shape involves knowledge of geometric figures (Clements, 2004). This can include recognition of two- and three-dimensional shapes. Some exploratory talk related to geometry was about shapes (25 [57%]). Some participants shared talk about shape recognition (9 [43%]). As students worked with small groups to identify which geometric shape held the most, Aaron predicted the square held the most. Chris corrected him, stating, “Cube.”

One error related to shapes was identified (1 [20%]). Aaron identified a shape as “um um triangle.” The other students disagreed, stating that it was a “square.”

Spatial Awareness/Location

Spatial awareness and location involves an understanding of space (Clements, 2004). It can include map learning, coordinates, and directions. This concept represented some of geometry-related talk (18 [41%]) made by some of the participants

(13 [62%]). During a small group activity, students had to listen to a series of clues about which cage the zoo animal should go in. After Alex placed the gorilla and tiger in cages next to each other, Adriana disagreed, suggesting that the animals needed to be switched because "she said the gorilla and the tiger will fight."

A few errors were identified (4) which represented the majority of errors related to geometry (80%). After hearing the clue "the elephant and the tiger are supposed to be in the middle cages", Steven placed the tiger in a cage that was not in the middle. He stated, "I do—I do know—this is gonna have to go right here and the tiger has to be back here!"

Putting Together Shapes

Putting together shapes involves understanding that shapes can be "decomposed and composed into other shapes and structures" (Sarama & Clements, 2006b, p. 40). One utterance related to the concept was identified in the geometry-related math talk (1 [2%]) by one participant (1 [5%]). While predicting which geometric figure would hold the most sand, Mia stated, "You can make a house with a square and a triangle." No errors related to this concept were identified (0).

Transformation and Symmetry

An understanding of transformation and symmetry means that the learner recognizes shapes can rotate and have lines of symmetry (Sarama & Clements, 2006b). No utterances related to this concept were found (0 [0%]).

Algebra

"Algebra begins with the search for patterns" (Clements, 2004, p. 52). The understanding of patterns can provide the foundation for algebraic thinking. Patterns begin with a core unit such as “AB.” From there, the pattern can either repeat such as ABAB, or grow such as ABABBABBB. Only a few utterances were related to algebra (9 [1%]) by participants (5 [24%]). No errors were found (0 [0%]).

<u>Repeating Pattern</u>

All utterances found related to patterning referred to repeating patterns (9 [100%]) These were made by some of the students (5 [24%]). During a whole group activity, Madison alternated connecting a set of black and white cubes in one long line. Megan stated, “Hey, Madison was doing a pattern with black and white.” During a small group activity, students had to identify how many farm animals were in the barn. Aaron placed four green tiles and one red tile above the picture of several farm animals. The following discussion occurred:

Aaron: 4 green legs. 1 red tail.
Right?

Chris: Hey, that's a pattern!

Aaron: Doing it a pattern.

One students shared a problem-solving idea related to patterning (1 [5%]). While working in a small group, Steven suggested the following idea to ensure that all students had a turn in class:

Steven: I'm trying to talk about like if they get mixed up. And somebody took somebody else. And they traded back um to each other the same ones that they just had.

PR: Um, so where do you think we should keep the cubes so that they don't get mixed up?

Steven: Behind them and like in a pattern.

No errors with algebra were found (0 [0%]).

Growing Pattern

There were no utterances identified related to growing patterns (0 [0%]).

Finding 2: The overwhelming majority of participants had speech disfluencies in their exploratory talk (20 [95%]. Most participants used "um" (20 [95%]), had pauses (19 [90%]), abbreviations (17 [81%]), and repetition (17 [81%]). Some participants used "like" (15 [71%]) and "uh" (15 [71%]) in their talk. A few participants had false starts (9 [43%]) and overlapping speech (5 [24%]).

The majority of participants had speech disfluencies in their exploratory talk which included "um" (20 [95%]), pauses (19 [90%]), abbreviations (17 [81%]), and repetition 17 [81%]). Some participants used "like" (15 [71%]) and "uh" (15 [71%]) while a few had false starts (9 [43%]) and overlapping speech (5 [24%]). Table 4.2 displays the results of the data analysis.

Table 4.2 Speech Disfluencies

SOUNDS LIKE	Number of participants
Speech Disfluencies:	**20 [95%]**
"Um"	20 [95%]
Pauses	19 [90%]
Abbreviations	17 [81%]
Repetition	17 [81%]
"Like"	15 [71%]
"Uh"	15 [71%]
False start	9 [43%]
Overlapping	5 [24%]

Um

The overwhelming majority of participants used "um" at times in their exploratory talk (20 [95%]). During a whole group lesson, Chris stated, "Um Max has the longest" . While sharing an explanation during a small group activity, Madison suggested, "Um if there's probably three in there um 'cause and seven there um three um is gonna um make one more um."

Pauses

The majority of participants had pauses in their exploratory talk (19 [90%]) such as Stacey who explained, "(pause) 'cause all of them right order". Other examples include, "We can uh see (pause) who we can count the (pause) wrapper and see how much is on there ” (Megan) or when Aaron counted, “1, 2, 3, 4, 5, 6, 7, 8, 9 (pause) we’ve got (pause) we’ve got 10, 11.”

<u>Abbreviated Speech</u>

Many participants had examples of abbreviated speech in their exploratory talk (17 [81%]) such as Alex’s explanation of “This one holds the most ‘cause it’s heaviest” and Megan who stated, “We can give ‘em two.”

<u>Repetition</u>

The majority of participants had repetition of words and phrases in their exploratory talk (17 [81%]). This included Alvin who explained, “If someone has a card, then that that reminded we already had a turn” and Kristina who suggested, “We could we could put um cards right there.”

<u>“Like”</u>

Some participants used the word “like” in their exploratory talk (15 [71%]). While weighing objects in a small group, Aaron stated, “It’s not heavy, it’s like this heavy” . During another activity, Alex suggested, “Like—put sand in them and like just hold the the cups.”

<u>“Uh”</u>

“Uh” was found in the exploratory talk of some participants (15 [71%]) including Stacey who suggested, “Uh (pause) we can use cubes” or Tiara who stated, “‘cause uh ‘cause if we put that one in there that one will be full.”

<u>False Starts</u>

A few participants had false starts in their exploratory talk (9 [43%]). These included phrases that went nowhere such as when Javier challenged, “There wasn’t there wasn't en—(pause) 'cause all of it didn't go in there!" or Kristina's explanation of "Because um the tiger—the elephant are huge."

Overlapping

Overlapping speech was found in a few participants' exploratory talk (5 [24%]). During a whole group activity, Megan stated, " Um, we can um add more cubes to um the to those cubes (points to 4 cubes in middle of carpet) and um then." Madison interjected, stating, "That's what I said!" Another example occurred during a small group activity: Steven stated, "one of those are bigger" and Kristina overlapped his speech, stating, "This one is probably the biggest."

Finding #3: All 21 participants shared their ideas using exploratory talk (100%). The overwhelming majority of participants offered statements for joint consideration (20 [95%]). The majority of participants challenged others' ideas (18 [86%]), set up hypotheses (18 [86%]), gave requests for clarity (16 [76%]), and had joint agreements (16 [76%]) in their talk. Some participants used evidence to support their thinking (15 [71%]), drew conclusions (14 [67%]), provided alternate theories (13 [62%]), and revised their thinking (11 [52%]).

All research participants shared their ideas in their exploratory talk (100%). Statements offered for joint consideration were also found in the overwhelming majority of participants' talk (20 [95%]). Many participants challenged others (18 [86%]), set up hypotheses (18 [86%]), gave requests for clarity (16 [76%]), and had joint agreements (16 [76%]). Evidence used to support thinking (15 [71%]), drawing conclusions (14 [67%]), offering alternate theories (13 [62%]), and revisions (11 [52%]) were also found in some participants' exploratory talk. Table 4.3 displays the results of the findings.

Table 4.3 What Does Exploratory Talk Sound Like?

SOUNDS LIKE	TOTAL
Shares/explains ideas	21 [100%]
Statements offered for joint consideration	20 [95%]
Challenges others' ideas	18 [86%]
Sets up hypotheses	18 [86%]
Joint agreement	16 [76%]
Seeks clarity	16 [76%]
Uses evidence to support thinking	15 [71%]
Draws conclusions	14 [67%]
Offers alternate theories	13 [62%]
Revises thinking	11 [52%]

<u>Shares and Explains Ideas</u>

All 21 participants shared their ideas through their exploratory talk (100%). This included students simply sharing their thinking, such as by counting objects.

PR: Okay. Now do you think we're done? Ivan, why don't you come count? We'll see how many feet we've got. Here comes--go ahead and start here. Can you guys help Ivan?

Ivan: 1 2 3 4

PR: 5

Ivan: 5 6

PR+Ivan: 6 7 8 9 10

Ivan: 11

PR+Ivan: 11 12 13 14

PR: Hey, did we have enough feet?

Students: Yeah!

During an observation, Madison and Adriana noticed that a numbered card for the calendar was missing. They took a card out of the calendar pocket and cut a piece of paper to match. They worked together to draw a picture of Abraham Lincoln that was on the missing card. When finished, Madison suggested, “You need a small number to match.” The students wrote the number “21” on the card and inserted it into the empty pocket on the calendar.

Most of the participants shared explanations (20 [95%]). After Adriana identified “Max” as having the longest object, she explained, “‘cause it had five rulers.” During a small group lesson, students ordered zoo animals from lightest to heaviest. Next, they predicted which food bag should go with each animal based on weight. After identifying that bag “C” was heavier, students were asked which animal should have the bag. Chris answered, “Um the tiger”, explaining “because the tiger is bigger than the monkey.”

Some students shared how they solved problems (11 [52%]). After Kara stated “My answer was we need three more”, she explained, “I just um thought about it myself and I started counting the thing (makes a horizontal line with hand) and I had seven then pulled apart three more and that made 10.” At times, students’ explanations revealed some inconsistencies (6 [29%]).

Aaron: We have three-three bodies.

PR: There's three body parts. Right.

Aaron: Three plus three is six.

PR: Now do we have enough legs?

Aaron: Yeah.

PR: We do? I just count 1 2 3 legs.

Aaron: No we put the green and red together--that makes six!

PR: Well, I thought Chris said the red was the body.

<u>Statements Offered For Joint Consideration</u>

The overwhelming majority of participants offered statements for joint consideration (20 [95%]). These included statements offered to the group to consider as they worked together to solve problems. As students shared suggestions for determining the total number of noses in the classroom, Colby voiced, “Um we can um like put tally marks (points to chart) we can like stand up and put some tally marks and sit down.” While working in a small group, students were asked to think of ways to figure out what’s inside the creepy crawlie jar. Steven suggested, “We could draw what the-there.”

Other times, students built onto others’ ideas as they made suggestions for the group to consider (15 [71%]). During one activity, students shared ideas on how to vote fairly. After an idea for using cubes and paper had been shared, Chris suggested the following:

Chris: You can like um have a paper and we can write our names and we can put cubes on the paper

PR: Okay. So write names on paper and then what?

Chris: And then we can vote and we can see (pause) we can

PR: Well let's back step a minute. We can write our names on paper

Chris: And you can put the cubes on them and we can see

PR: Will that help us see who's voted?

Chris: Yeah and we can see um if they have a paper and they put the cubes around the paper, um, on the paper and that's means they already had a turn.

PR: Okay so we'll be able to tell who's had a turn if the cube is off their paper.

Chris: Yeah.

During one whole group episode, students identified ways to determine how many eyes were in the classroom. After one student suggested counting out two cubes for each student, Adriana continued the idea, suggesting placing the cubes “um in front of us.” When asked how the students might keep track of the number of eyes, Megan stated, “Um we can keep um the things in front of us and then put them behind” as they were being counted.

A few of the joint considerations became clearer as students explained their ideas (3 [14%]). During a small group activity, students shared ideas on identifying the total number of cookies eaten in class. Chris suggested, “Um, we can count by two's and see how much there were and we can use um these” (points to colored tiles). He continued, “Yeah and then we can put them and we can put 'em (pause) and we can use a paper and we can put them on here.” He finished by stating, “on the paper.” Other times, students were asked to restate their idea to the group (3 [14%]).

Madison: Uum we can um see um that um how many cookies that were in the box and if we and iihh if we just forgot if we just forgot how to, we could take them out and then put them on the plate and then if um if that's enough and when you tell us to stop, that means that's how many cookies there was.

PR: Okay. So did you understand what Madison said? Does someone want to ask her a question? Megan?

Megan: Um what did you say?

PR: Can you say it in a different way?

Madison: Um I said we could put them by groups um down and then um um when you tell us to stop, we could stop and figure out how many we have.

Some of the talk revealed students restating their ideas if they were misunderstood (3 [14%]). After Megan originally suggested an idea to identify what kind of classroom party to have, the following discussion occurred:

PR: So that means on our pieces of paper, we need to do/Megan: No, I said

PR: what?

Megan: I said that we write we write our favorite things and if the paper goes the highest (puts hand in air)

PR: Yeah.

Megan: Then and then you get to try (points finger in air gradually going higher) which one's the highest.

Challenges Others' Ideas

Many participants challenged others' ideas in their exploratory talk (18 [86%]). During a small group activity, students suggested ideas to determine the number of chairs needed for a party.

Javier: Umm you can like count the little things that stand them up.

PR: Oh so you can count the chair legs. Okay. Now how many chair legs do you think there are on a chair?

Kristina: Four.

Javier: Uuh. 24.

PR: Do you guys agree or disagree?

Kristina: Disagree.

PR: Why do you disagree?

Kristina: 'Cause 24 legs is too many.

PR: Okay so how many legs do you think there are?

Kristina: Four.

During another episode, one student suggested adding one more counter to make a set of nine legs. Aaron stated, "We don't need nine!" He continued, "Spiders don't have nine legs. They have eight legs so that's one spider with eight legs."

A few participants discovered their challenges were incorrect (2 [10%]). After Alvin drew seven lines on a piece of paper, the following dialogue began:

Students: Uuh. No.

PR: No? Talk it over with Alvin.

Madison: I think there's six.

PR: You think there's six? How could you show me what's the problem?

Madison: 1, 2, 3 . . . 7

A few participants helped each other identify how the mistake was made (2 [10%]). During one activity, Mia shared that there were five days of school left during one week on the calendar. Adriana challenged her answer, stating to Mia, "'cause that one we're not supposed to." She further explained, "'cause that one means we're off", referring to Sunday on the calendar.

A few students challenged their peers while suggesting why the answer was given (2 [10%]).

Kristina: And then I think this one goes next and then this one and then

PR: Okay and then Kristina showed us--this one's called a rectangular prism. Wanna put that one right there?

Javier: No, I think these ones are the same size

She wants those to hold more

Sets Up Hypotheses

The majority of participants set up hypotheses in their exploratory talk (18 [86%]). While attempting to identify how many cubes were in the mystery bag, Chris stated, "I think that remember, you started with 10. Maybe I think took three away and sounds like one is in there but I think they are hooked together." Other times, a few students worked together on forming their hypotheses (4 [19%]). During a small group activity, some students were puzzled by what was inside the creepy crawlie jar. After noticing that two counters were leftover, the following conversation occurred:

Aaron: Spider!

PR: Why do you think it might be a spider?

Chris: Spi-ders!

PR: I know but why do you think it's a spider?

Aaron: ‘Cause it doesn't say any

Chris: Sometimes spiders crawl.

PR: Okay/Chris: And they're kind of creepy.

Joint Agreement

Some participants had examples of joint agreements in their exploratory talk (16 [76%]). During one activity, Jamie and Kara were discussing whether a scorpion was an insect. When asked what they had decided, they both stated, “It’s not” while Kara continued, “an insect.” While identifying the animals hidden in the mystery barn, Chris suggested they had too many tails. Aaron voiced, “Oh you know, I think he's right.”

Seeks Clarity

Some participants sought clarity in an attempt to understand others’ ideas (16 [76%]). Madison disagreed with another student’s answer, stating, “There two um tails and um what’d she say?” The student was then able to explain her idea again. During a small group activity, Chris shared an idea he had about making sure everyone had a turn in the classroom. The following discussion occurred:

Colby: How're you gonna do that?

PR: How are you gonna do that. That's a good question.

Chris: Uum. Let's pretend let's pretend um uum uum you put something right here and and you can put one right here, right there. Yeah, put the squares. That'd be better.

PR: And would those stand for people?

Chris: who haven't

PR: So everybody who has not had a turn, has a cube. Okay.

Chris: Whoever doesn't have a cube, they already had a turn.

PR: Okay. So let's say you had a turn, so what would you do with your cube?

Chris: I would think put it right on here and if (pause) if you and

PR: Oh so if you get more than one turn, you get a second cube. Okay. Does that make more sense to you Colby?

Colby: Yeah.

A few participants shared clarity-seeking questions and statements as they worked together (4 [19%]). Aaron and Todd were working together to represent their idea. Aaron was drawing a picture of the classroom carpet on a sheet of paper. Aaron was asked how he could include Todd in the process, resulting in the following dialogue:

Aaron: Well he could get a pencil and with an eraser, well

PR: Or a crayon? Will a crayon work?

Todd: And the crayon goes where?

PR: Okay, talk it out guys. What do you want him to do? Tell him.

Aaron: Okay, I'm drawing with a pencil by it and get a red crayon and there's another red crayon, just get it and because I need another red crayon like this.

Todd: Purple (sound of crayons in can)

Aaron: We can't use another color than this because this is the red row. Right?

Todd: Huh?

Aaron: This is the red row.

Uses Evidence To Support Thinking

The majority of participants used evidence to support their thinking (15 [71%]). Some of the evidence was students' use of prior knowledge, such as when students had to order animal pictures from lightest to the heaviest. Tiara stated, "This one's the biggest 'cause it's bigger than this one, this one this one and this one" referring to the picture of the elephant. Todd suggested that the mouse should be first, explaining, "The the mouse weighs um like one pound." During a small group activity, Chris suggested using tiles to build an insect model:

PR: Okay go. How are you gonna use the tiles to guess what's inside my bag?

Chris: You can use the greens for the feet,

PR: Okay

Chris: the reds for the body, and the blue for the eyes.

PR: Okay, do we need to count the eyes?

Chris: and the yellow for the um antennas.

During one small group activity, Madison suggested, "Um if we had a balance we could balance balance them and see which one's the biggest one" while attempting to identify which shape held the most.

A few students used demonstration to support their answers (3 [14%]).

PR: And then I heard at the end, Aaron said this square held more. How did you know it held more?

Aaron: Well, let's try this one more time.

PR: Okay go ahead and show us.

(sound of sand pouring)

Aaron: ‘Cause that one's gonna hold that (more sand pouring)

PR: Okay. So we filled up the cube. And now we're gonna try the-- hexagon prism

Aaron: Hexagon prism

PR: And what's gonna happen Aaron?

Chris: Sand is falling down

Aaron: See that side

(sand pouring)

See?

PR: Oh so what did we see?

Aaron: Sand fall down.

PR: So which held more?

Aaron/ students: the squ/the square

Draws Conclusions

Drawing conclusions was found in the exploratory talk of some participants (14 [67%]). After identifying the total number of cookies eaten in class, the following discussion occurred:

Javier: 1, 2, . . . 16

PR/Students: 17, 18, 19, 20, . . .

Javier: 23, 24, . . . 36, . . . 40

PR: And what about our leftover one? Who has it?

So what would that make?

Javier: 41.

PR: So do you think there was 41 cookies yesterday?

Jamie: Uuuh 20.

PR: Okay. Well, how many cookies did we just say?

Javier: 41

PR: Did we say 20 cookies or 41?

Javier: 41

PR: 41 cookies. Why do you say that, Javier?

Javier: Um because there's 41 unifix cubes. There's 41 cubes.

During a small group activity, students predicted that the cube would hold the most. After brainstorming strategies, the students worked together pouring sand from the cube into other geometric shapes. Steven poured sand from the cube into the cone, noting that some sand was still left inside the cube although the cone was full. He concluded that "the cube" held more.

Alternate Theories

A small number of participants offered alternate theories in their exploratory talk (13 [62%]). These included the introduction of new thinking into the dialogue such as Michael, when asked to help Aaron keep track of the number of cubes, suggested, "Let's count them in your head." Another example included Jamie who voiced, "We could um (pause) see which one holds the mostest with the sand" while the remaining members of his team argued about which geometric shape was the biggest.

<u>Revisions</u>

A small number of participants revised or changed their thinking as a result of problem-solving activities (11 [52%]). During a small group activity, students worked together to order the zoo animals from lightest to heaviest:

Chris: Tiger is like 10 pounds.

Todd: Tiger is not 10 pounds it weighs more!

Chris: I think the tiger weighs like 20 pounds.

Other examples revealed students recognizing their own errors (2 [10%]). After hearing the clue "the gorilla and the tiger will fight if they're next to each other", a student placed the animal figures into four different cages. The following discussion occurred:

Alvin: No I disagree.

PR: Do you guys agree?

Okay Alvin says he disagrees.

Why?

Alvin: It's just because they they they (makes noise) they right here.

PR: You think it's supposed to go in the middle?

Tiara: It's supposed to go down here 'cause they're gonna fight.

PR: Oh so they can't be together can they? Okay.

Alvin: I thought they would fight if they were in the same box.

When asked to predict which geometric shape would hold the most, Javier voiced, "Like sand will be um ca-there's more sand in there cause this one is the size of that one. I think there—they should hold the same size." Later on, when asked to explain why the cube held more, he stated, "There wasn't there wasn't en-cause all of it didn't go in there! Yes cause it wasn't the same--I thought it was. But it wasn't."

Finding #4: The majority of students used their hands and fingers as they engaged in exploratory talk (15 [71%]). Many participants used gestures, including pointing (15 [71%]). A few participants gestured as they dramatized part of their response (7 [33%]). Some participants used their fingers to solve problems (9 [43%]).

One interesting finding was that the majority of participants used their hands and fingers as they shared exploratory talk (15 [71%]). Many participants used gestures, including pointing to objects as they stated their responses (15 [71%]). A few participants gestured as they dramatized parts of their talk (7 [33%]). Some participants used their fingers to share answers or solve problems (9 [43%]).

<u>Gestures</u>

<u>Pointed to Objects</u>

The majority of participants pointed to objects as they shared exploratory talk (15 [71%]). Madison suggested, "Um we um can put out some cubes (points to cubes) next to that" (points to ruler). Kara explained, "Because (pause) um we can't count those two (points to calendar) because um because actually Friday we don't have school so."

<u>Dramatization</u>

A few participants dramatized part of their exploratory talk (7 [33%]). Megan suggested, “We um we can grab a piece of—a square paper and write down our favorite food” (moves finger across carpet). Steven explained why a scorpion wasn’t an insect, stating, “They have (holds hands out to side and opens and shuts hands) they have these two things” (points to pinchers on the picture of the scorpion).

<u>Use of Fingers To Solve Problems</u>

Some participants used their fingers as they engaged in exploratory talk (9 [43%]).

PR:	Okay are you gonna figure out --have you figured out how many more counters we need for our party?
	(ACTIVITY) Student nods head.
PR:	Show me that answer.
Javier:	10 more.
PR:	Do we need 10 more?
	(ACTIVITY) He looks down then shows three fingers.
Javier	Three! Yeah three!
PR:	Okay, show me how you came to that answer.

During a whole group activity, Kara suggested there were two pigs in the mystery barn. When asked to explain her thinking, she stated, “And um I think he counted them like two times unless um two times so that um makes (shows four fingers on each hand) so four plus four equals seven.”

Finding 5: A large amount of exploratory talk utterances were found (1473) which occurred during small group activities (960), whole group lessons (506), and

observations (7). All 21 participants engaged in exploratory talk during small group (100%) and whole group activities (100%). A small number of students had examples of exploratory talk during observations (5 [24%], including calendar (1 [5%]), math activities (1 [5%]), snack preparation (3 [14%]) and a class meeting (2 [10%]).

A significant amount of exploratory talk was identified in the classroom discourse (1473). These utterances were found in small group activities (960), whole group lessons (506), and during observations (7). All 21 participants engaged in exploratory talk during small group (100%) and whole group activities (100%). A small number of students had examples of exploratory talk during observations (5 [24%], including calendar (1 [5%]), math activities (1 [5%]), snack preparation (3 [14%]) and a class meeting (2 [10%]). Table 4.4 presents the research findings.

Table 4.4 When Does Exploratory Talk Occur?

Format	**Number of participants**	**Number of Exploratory Talk Utterances**
		1473
Small Group:	**21 [100%]**	**960**
Whole Group	**21 [100%]**	**506**
Observations	**5 [24%]**	**7**
Calendar	1 [5%]	1 [14%]
Math activities	1]5%]	1 [14%]
Snack preparation	3 [14%]	3 [43%]
Class meetings	2 [10%]	2 [29%]

Note: percentages are not provided for the number of exploratory talk utterances as the comparison base is not equal (i.e., four weekly small group activities; one or two weekly whole group lessons; five observations).

<u>Small Group Activities</u>

A large amount of exploratory talk utterances were found in small group discourse (960). All participants had examples of exploratory talk utterances in small groups (100%).

<u>An Example of Small Group Exploratory Talk</u>

During one activity, group members engaged in exploratory talk as they tried to figure out how many items were in the mystery bag. Exploratory talk utterances are highlighted.

PR: I'm meeting with group four, finishing up week six. Can you say your name?

Aaron: Aaron.

Chris: Chris

Todd: Todd

PR: Good. Well, we solved the problem last week with the mystery bag. And guess what, the mystery bag is back. You have to figure out how many things are in it. Okay, listen (sound of item inside sack being shaken). Hmm, I wonder how many things are in there. Do you have enough information though?

Students: Hmm.

PR: Let me show you how many I ended up with first.

1, 2, 3, 4, 5, 6, 7. I have seven leftover, here's my sack (shakes sack) and I started with 10. How many's in my sack?

PR: Todd, you say there's 1. Why do you think there's 1?

Todd: 'Cause I hear sa-- one thing in there.

PR: Todd hears one cube. Do you guys agree? Is there one in here?

Aaron: No.

PR: Aaron, you say you disagree. Why do you disagree?

Aaron: Because um you started with 10 and you started with 7 and it goes to 8, 9, 10.

PR: Oh, so you think there's got to be more than one in here.

Chris, what do you think?

Chris: Um, there there

I think that remember, you started with 10. Maybe I think took three away and sounds like one is in there but I think they are hooked together.

PR: Oh. Very clever. Okay, how could we find out for sure? Could we use these cubes to figure out our answer without looking in the bag? What could we do, Aaron?

Aaron: Um, we could count them right out here and get some three more and put it right here.

PR: Okay. So you want to try that? So Aaron's gonna get three more.

Aaron: 1, 2, 3.

PR: Okay Aaron, tell me what you're doing.

Aaron: Then I'm gonna put them right here and then I'm gonna stack them up together.

Todd: How does that come out?

Chris: Did you count this?

Students: Um. 10. 10!

PR: Okay, now Aaron took the three and added it to our seven. What does that add up to?

So is that 10? Do you guys agree? Should I --

Students: Yes!

PR: is there three in my sack?

Okay, shall we let Todd look?

Okay Todd, look inside.

Todd: They're all hooked together!

PR: Hmmmm! Now bring it out. Show it to everybody. Show it to your group. Oh, so were we right?

Students: Yes!

PR: Okay, who wants to write your answer? You guys solved that question really fast. Since Chris got to, I'm sorry, Aaron got to do a lot of counting, we'll let Chris write it and if you agree with Chris, you may sign your name to the paper. Good work today. You guys solved that fast!

Whole Group Activities

Some exploratory talk was found in the whole group discourse (506). All participants shared exploratory talk utterances during whole group activities (100%).

During whole group activities, the students and teacher worked together to solve problems using exploratory talk. The following lesson took place during week six of the research study. Highlighted items indicate examples of exploratory talk.

An Example of Whole Group Exploratory Talk

(ACTIVITY) Students are seated on the carpet facing an easel/chart. PR walks across carpet and stands by easel/chart. Points to chart that states 'Talk Chart'.

PR: Okay, who sees a rule we talked about?

(ACTIVITY) 2 students raise hands.

Umm Tiara? Do you remember any of our talk chart rules?

(ACTIVITY) Tiara points to 6th rule on chart.

PR: It says (points to each word) work together on ideas. Do you guys think we do that one pretty well?

Students: Mmhm.

PR: Let's just read them all real quick. (points to first rule on chart; a few students join in): We listen. Take turns. Don't interrupt. Let everyone talk. We are nice. Work together on ideas. If you understand, ask. And if you disagree, be kind.

Well, I noticed one that we did last week and you guys helped me with that. What if I'm talking and I get stuck, did you guys help me?

Kristina: Yes.

PR: So if someone gets stuck on ideas, can you help 'em out? What do you think?

What?

Students: Yes.

PR: Yes so if someone (begins to write on chart) gets, what's my word?

Students: stuck

Student: on

PR: Help them out. I can help them out by saying, “What do you mean?” or I can even add to their ideas.

Who can raise their hand and say to me their favorite colors?

(ACTIVITY) Majority of students raise hands.

Steven.

Steven: Blue

(ACTIVITY) PR puts face behind easel.

PR: Hmm, hmmm.

(ACTIVITY) PR comes out from behind easel and looks at students.

Did you say something?

Steven: Yelp!

PR: Was he talking to me?

Students: Yes.

PR: Oh so you mean when someone's talking to me, should I show 'em I'm listening?

Alvin: Blue.

PR: So how could I show Steven I'm listening? What could I do with my body? Megan?

Megan: Um open up your ears.

PR: So I can make sure my ears are open (holds hands by ears). What else should I do if Steven's talking? Javier?

Javier: Um look at him.

PR: Oh that's a good one. So I could maybe look at him. So could you guys show me that?

(ACTIVITY) Students turn around and look at student [Steven].

So if Steven's talking, so we're gonna look at someone when they're talking. How else can we show that we're listening?

(ACTIVITY) Student [Aaron] puts hand in air.

Aaron, what do you think?

Aaron: Um we can listen by when somebody's talking

We can not interrupt.

PR: Oh that's a good idea so we can not interrupt him. We want him to keep talking. Sometimes though if like Miss Amy's talking, I might say, "Yeah, Miss Amy", I might help her when she's talking. So I want you guys to help me think about . . . how we can show we're listening.

Well, here's my tricky problem. I'm gonna wait for everyone to turn back around and face the middle of the carpet 'cause you know what happened to me last night? I went to the store and this is what happened (PR stands up). I'm gonna show, I'm gonna act it out.

(ACTIVITY) PR leaves camera range; students turn and watch.

I had a bag (PR returns holding a blue bag that is folded at the top) of stuff and I had four in my hand (PR kneels down and joins circle; shows four counters).

Now, I wonder if there's any way I could figure out how many things are in my sack without opening the sack?

What could I do? Now I know there's something in here (shakes sack) and I know I have four in my hand (shows four cubes stuck together in a train). How could I figure out how many things are inside my sack?

(ACTIVITY) Megan raises hand.

Megan, what do you think?

Megan: Um, you could um ask um Miss Amy for the number.

PR: So I could ask somebody to help me. But what if I don't let anybody peek inside?

They have to just be tricky and try to figure out. I know I have four. How many things are in my sack?

(ACTIVITY) 2 students [Aaron and Javier] raise hands.

Javier, what could I do?

Javier: Um

You could take the cubes (cups hand on carpet) and try to guess it.

PR: Mhhmm.

Javier: You can like give a number and see if it's right.

PR: Okay so somebody could say a number and then I could figure it out that way.

Okay.

Javier: And then if you get it right, you can look.

PR: Okay but you know I'm not sure how many are in here either. I forgot.

Hmm. How could we figure it out. Tricky?

(ACTIVITY) Several students raise hands [Alex, Todd, Aaron]

Do you have an idea Todd?

Todd: Um (pause)

PR: I know there's something in here (shakes bag) and I know I have four cubes (places cubes slightly apart on the carpet). How could I figure out how many things are in my sack?

Todd: Mhhmm

PR: Hmmm, is that tricky?

Todd: Yeah!

PR: Yeah. Pretty/Todd: Four!

PR: tricky. You think there might be four?

(ACTIVITY) Student [Todd] nods head.

Okay. Why do you think four?

Todd: (pause)

Kristina: (points to counters on floor) ‘Cause there's four.

PR: You think ‘cause there's 4 right there?

(ACTIVITY) Kristina and Todd nod heads.

So it might be a double? Okay. Anybody have another idea?

(ACTIVITY) Student [Aaron] raises hand.

Aaron: If you can count just one, maybe there's just one in there.

PR: You think there might be just one more. Well, let's listen (shakes sack; many cubes are heard moving around inside sack). Do you think there's one or maybe more than one?

Students: More than one!

PR: Oh, I think you might be right Stacy. Okay, Chris, do you have an idea?

(ACTIVITY) Student [Chris] shakes head ['no'.]

PR: No. Well, what if I told you this information, ---.

What if I started with 10 things. I put some in my sack (shakes sack) and I know I have four (shows four cubes in hand) left over. How could I figure it out then?

I wonder how I could figure it out. (PR raises hand). Quiet hand. Who thinks they know. How many things are in my sack?

Mia, what do you think?

Mia: Hmm

(pause) Eight.

PR: Okay. How did you figure that out? Mia thinks there might be eight things.

Mia: (pause; no response)

PR: Not sure? You wanna think some more on that?

(ACTIVITY) Student [Mia] nods head; two students [Stacy & Alvin] have hands up.

Okay, Stacy has a good hand.

Stacy: (no response; looks at PR)

PR: What could I do to solve this problem? I know you've had a busy day and you guys look kind of tired. Wonder what we could do to figure how many things are in Mrs. Bequette's sack without looking inside.

(ACTIVITY) Students non-responsive.

Hmm. Nobody has an idea.

Aaron, what could we do?

Aaron: Um, we could dump that stuff out and count 'em with the cubes.

PR: Yeah, would that be peeking though?

Aaron: Yes (hides face)

PR: So you can't peek. How many did we start with?

Aaron: Four.

PR: Well, how many things did I start with?

Students: 10!

PR: Ten. I put some in my sack (shakes sack) and I have four left over.

(ACTIVITY) Student [Alvin] raises hand.

Alvin: Ohhhh, I think I know!

PR: Alvin, what could I do?

(ACTIVITY) Student [Alvin] pauses; no response

(ACTIVITY) Student [Chris] is placing one finger up at a time. He raises hand then puts it down.

Alvin: I forgot.

PR: You forgot? Okay Alvin's gonna think some more. What if, okay, it looks like we're kinda stumped. So I'm gonna put a tool out here. I wonder if we could use this tool to help us solve this problem?

(ACTIVITY) PR places tub of counters on carpet.

Okay, so here's some cubes. I know I started with 10. I put some in here and four are left.

(ACTIVITY) Several students raise hands.

Madison, what could I do?

Madison: Um, you can put um in front you can count um how many's in there how many's in there you gotta put um you gotta put some in there and count how many's down.

PR Okay, so I think what Madison's saying is we need to put some out? (points to cubes in center of carpet).

(ACTIVITY) Madison nods head.

Now who could add to Madison's idea? How many do we need to put out?

Megan?

Megan: Um, we can um add more cubes to um the to those cubes (points to four cubes in middle of carpet) and um then/Madison: That's what I said!

PR: [to Madison] Oh good!

Megan: you can add um more cubes and you make um that those cubes um to 10.

PR: Okay. So Megan has one idea. She says that we can add cubes (points to four cubes laid in a row on carpet) to make 10 and see how many cubes we would have? So was that your idea too, Madison?

Madison: No.

PR: No okay. How was your idea different?

Madison: Shaking the bag out here and put some of the cubes out here (points to carpet).

PR: Ohhh! But I'm not gonna let you peek in here for a little while. Okay.

(ACTIVITY) Student [Chris] raises hand. PR points at him.

PR: Chris, what could we do?

Chris: I know I think I know how many's in there.

PR: Okay, don't give the answer away!!

Yeah, I wanna know how we could figure it out as a class.

(ACTIVITY) Student [Kristina] raises hand.

Kristina?

Kristina: Put four out there (points to carpet)

PR: Okay so Kristina says we need to put four out there. Who thinks there's four in here or maybe more or less? What do you guys think?

(ACTIVITY) Student [Stacy] raises hand.

Stacy, what do you think?

Stacy: More.

PR: More. Why do you think there might be more?

Stacy: (No response)

PR: I wonder why she thinks there might be more than four? Does it sound like maybe more than four? (shakes bag)

(ACTIVITY) She nods head [yes]

Hmm, okay. Well, let's go back to Megan's idea. She said to add cubes (points to tub of cubes) to this set (points to four cubes) to find out how many might be in the set. So how many are we going to count up to, Megan?

Megan: 10.

PR: Okay, so what are we at right here (points to fourth cube)

Megan: Uh

PR: What?

Megan: Four.

PR: Okay do you wanna come add some and we'll see?

(ACTIVITY) Student goes to middle of carpet; she takes one cube from the tub.

PR: Okay so what are we at?

We're at four. What comes after four?

Megan: (puts down fifth cube in the line)

PR: 5

I wanna hear you guys help me count.

(ACTIVITY) Student adds another cube to set.

PR+Students: 6

PR: We're all helping!

(ACTIVITY) Student continues to take one cube from tub and add it to the line.

PR+Students: 7, 8, 9, 10.

PR: Okay, so we've got 10 cubes. Huh, did we figure it out? Did we solve it?

Who says no?

What do we need to do with the 10 cubes?

Kara, what do you think we need to do with the 10 cubes?

Kara: (pause)

PR: We know Mrs. Bequette had four left over. How could we figure out how many's in my sack?

Kara: (points to each of the cubes) Um

PR: What were you doing? I saw you doing something?

Kara: I counted the four and um there's six right there.

PR: Okay, so we have four (shows four cubes) and then we have six (points to six cubes). So do you think there's six in my sack?

(ACTIVITY) Student nods head.

Students: Yes.

PR: Why do you think that?

Kara: Because (pause) there's six and four right there (points to cubes)

PR: So do you think four and six together make 10?

(ACTIVITY) She nods head.

PR: Okay. Now what do you guys think? Do you agree with Kara (shows thumb up) or do you disagree (shows thumb down)?

(ACTIVITY) Many students show thumbs up; a few show thumbs down

Okay, I see a lot of agrees. Javier, what do you think?

Javier: Um

PR: Do you think she's right?

(ACTIVITY) Javier nods head 'yes'.

Do we wanna look inside?

Students: Yeah!!

PR: Are you sure you wanna look!

Students: Yeah!!

PR: Okay Kara, come and look.

So she thinks there's six.

(ACTIVITY) Student [Kara] goes to middle of carpet towards sack.

I would be so glad if you could solve this problem. I wanna know how many things I put in my sack!

(ACTIVITY) She looks inside sack. Then turns to PR.

Kara: There's six.

PR: Okay, you wanna prove it to us? We want proof, don't we guys?

(ACTIVITY) Many students nod head.

(ACTIVITY) Student reaches into sack and takes out one cube at a time. She places the cube away from the other cubes on the carpet.

PR+Students: 1

(ACTIVITY) Student continues to withdraw one cube at a time and place it next to the previous cube in a straight line.

PR+Students: 2, 3, 4, 5, 6

PR: Was she right?

Students: Yeah!

PR: Let's clap for everybody!

(ACTIVITY) Students clap hands.

Wow!

(ACTIVITY) PR puts cubes in hand.

Alvin: I was wrong because I was about to say five.

PR: So were you getting close? Why did you think five, Alvin?

Alvin: Well, because I just thought that we had five but we just had six.

PR: Okay, well, good job today.

[Discourse removed —non consenting student]

PR: How did she know that? Kara, you want to explain it one more time?

Kara: I knew it because there were four and then there was um six so I counted on and it was six right there.

PR: Okay, so she kind of had two groups, didn't she? You had our first group was what, how many?

Chris: Four.

PR: Four and then how many did Megan add to make 10?

Chris: Six.

PR: six and together that made a total of

Student: Six

Students: Ten

PR: Was it a total of six or a total of 10?

(ACTIVITY) Students show 10 fingers

So you guys worked together. Nice job with that. Okay, let's talk about our math labs.

Observations

A small number of participants engaged in exploratory talk during observations (5 [24%]), including calendar activities (1 [5%]), math table activities (1 [5%]), snack time (3 [14%], and a class meeting (2 [10%]).

An Example of Observational Exploratory Talk

During snack time, a small group of students prepared the popcorn and juice for students to enjoy for a classroom party. After identifying how many students were present by looking at the student-created attendance chart, the group worked together to set out a matching number of popcorn sacks. Madison voiced, "One per sack" as the juice was passed out. Kristina suggested, "Put names on sacks to make sure everyone gets one." Stacey noticed that another student, Alvin, was gone. "Alvin's not here" as she removed a sack and juice.

Finding 6: Much of the teacher support was the use of reply not assess words (1306 [42%]). Some of the teacher support included the revoice of students' responses (677 [22%]) and the use of open-ended questions (561 [18%]). A small amount of teacher support was review (190 [6%]), the teacher acting as a peer (105 [4%]), leading students through their puzzlement (103 [3%]), informal use of math vocabulary (96 [3%]), and the use of tools to support thinking (46 [2%]).

An examination of the classroom discourse revealed that much of the teacher support was through the use of reply not assess words (1306 [42%]). Other types of support included revoicing student responses (677 [22%]) and using open-ended questions (561 [18%]). A smaller amount of teacher support included review (190 [6%]), the teacher acting as a peer (105 [4%]), leading students through their puzzlement (103 [3%]), the informal use of math vocabulary (96 [3%]), and the use of tools to support thinking (46 [2%]). Table 4.5 presents the research findings.

Table 4.5 Teacher Support

Descriptor	**TOTAL**
TOTAL	**3084**
Reply not assess	1306 [42%]
Revoice	677 [22%]
Open-ended questions	561 [18%]
Review	190 [6%]
Teacher as peer	105 [4%]
Lead through puzzlement	103 [3%]
Informal use of vocabulary	96 [3%]
Tools	46 [2%]

Reply Not Assess

Reply not assess words were found in much of the classroom discourse (1306 [42%]). The majority of these included the word “okay” (1028 [79%]). After Megan suggested, “We can give ‘em two”, the teacher replied, “Okay, do you think there’s enough to give everybody two cookies?” During a small group activity, Mia stated, “If they have a turn, they could put one of the butterflies and they can have one of those cubes." The teacher replied, "Okay, so if, do you guys understand or do you want Mia to explain it again?"

A small amount of reply not assess words included "oh" (212 [16%]). During a whole group lesson, Megan disagreed with Aaron's answer, explaining, "Because we need two more" to which the teacher replied, "Oh, how did you know?" While sharing ideas on how to keep track of the number of tiles counted, Tiara suggested, "We put them over there." The teacher responded, "Oh, so we could move them."

A few teacher support words included "well" (66 [5%]). While working with group two to identify how many creepy crawlies were in the jar, a participant suggested a spider. The teacher replied, "Well, if there's a spider, how many legs do we need?" During another activity, a few students suggested there were three items inside the mystery bag. The teacher stated, "Well, let's listen. Does this sound like three?" (sound of bag shaking).

<u>Revoice</u>

Some of the teacher support included revoicing student responses (677 [22%]). The majority of revoicing was in the form of a statement in which the teacher reworded what the student had said (450 [66%]). After Madison suggested Kristina's object was the longest, the teacher stated, "Okay. So Madison thinks 15 is bigger, that Kristina's object was the biggest." During a small group lesson, Jacob shared his idea for representing 22 objects.

Jacob: Umm, draw on a board.

PR: Are you going to make tally marks like on our board?

Jacob: Yeah with a marker.

PR: Jacob's going to use an erase board to show 22.

Some of the revoicing was done in the form of a question (176 [26%]). After Chris suggested that the five rulers would make the longest object, the teacher stated, “Oh so you think because the ruler's the longest, it's gonna be bigger than the other objects no matter what?” When asked to identify what students observed about spiders, Tiara stated, “Eight legs.” The teacher stated, “Oh so you think it has eight?”

A small amount of revoicing was written on a chart or board (51 [8%]). After Stacy suggested, “Um (pause) we can use cubes” to figure out the most popular kind of party in the classroom, the teacher stated, “Okay so Stacy says we’re gonna use cubes” while writing the response on chart paper. After Steven shared his answer of “ Um, I found out with four because we need four more”, the teacher continued, “Okay so Steven says we need four more” while adding his response to the board.

Open-Ended Questions

Teacher support in the form of open-ended questions were found in some of the classroom discourse (561 [18%]). Some of the questions began with “how” (210 [35%]), including this episode that occurred during a small group activity.

PR: We need to figure out which of these shapes holds the most. How could we figure that out? What do you think, Javier?

Javier: Um I think it should be the biggest one

PR: Okay. How can you tell which is the biggest since they're all different shapes?

During another activity, the teacher stated, “It was 20 students. So we have 20 students, everybody got two cookies, with one leftover. How could we show it with these tools?”

During a small group activity, students worked together to identify how to show 21 students in the classroom. Jamie stated, “So you could see whose the biggest and see whose the smallest.” The teacher stated, “Okay. Now remember that you want to show us guys that there’s 21. How could Jamie use his idea to show that there’s 21?”

Some questions began with “what” (178 [29%]). After identifying that there were too many feet in the barn, Tiara suggested removing the picture of the farmer. The teacher stated, “Oh he doesn’t have a tail. So what would happen if we took the farmer away?” After Madison counted out 10 cubes to represent the number of counters needed to earn a party, the teacher asked, “What do we need to do with the 10 cubes?”

Other questions began with “why” (150 [25%]). After Aaron suggested five more counters were needed, the teacher stated, “So you started with 6, 7, 8, 9, 10. Now why did you start counting with six?” During another activity, the teacher asked, “Chris, why do you agree?”

A few open-ended questions began with “I wonder” (23 [4%]). After students worked together to figure out there were three objects inside the bag, the teacher asked, “I wonder why you guys thought it was just one?” During a small group lesson, the teacher introduced the problem, stating, “I want to find out how many cookies there were altogether. I wonder what we could do?”

<u>Review</u>

Review represented a small portion of the teacher support (190 [6%]), including a review of the problem (105 [55%]). During a whole group activity, the majority of students agreed that the problem had been solved. However Chris disagreed, stating “Um, um this um there’s um a tail” while pointing to a picture of a chicken. The teacher replied, “Oh! We have too many tails? Well, how many tails are we supposed to have?” Another example occurred during a small group lesson as students suggested how to determine which shape held the most. Javier suggested, “Um we can fill-we can fill-we can fill all of them in with the shovel.” The teacher asked, “Now will that tell us which one holds the most?”, reviewing the initial question.

Some of the support included a review of previous ideas (60 [32%]). After asking how to determine the number of eyes in the classroom, Alvin asked, “(pause) What are we talking about?” The teacher replied, “Now Javier and Megan kinda had an idea where we would put cubes in front of us and then Colby thought we might do tally marks to double check. Do you have something different?” Alvin then suggested, “You can put it right behind us.” While working with group one on representing the number of students in the classroom, the teacher stated, “And I want to be able to see how many friends are here. So like one way was with the tally marks. That was one way. How else could we show 21? Ivan, what do you think?”

A few utterances related to review included modeling (25 [13%]). The teacher typically reviewed an idea by modeling or demonstrating it. After Kristina shared a way to tell who had had a turn in the classroom, the teacher continued, “Okay. Do you understand so far? So put a card by our spot if we’ve had a turn. So like right now, Kristina’s had a turn, so would we put a card there? But Mia hasn’t had a turn, so I could tell by looking around the carpet that she hasn’t had a turn. So that’s a different idea . . .” While working with group one to determine which shape held the most, the following conversation occurred:

Tiara: Well, we can put all this--we can put half of the sand in all of them and see which one holds the most.

PR: So if I put sand in here and put sand in here, how will I tell which one has the most sand? (sound of pouring sand)

Megan: We can see how much sand that equals that one cup/Tiara: We can get that one cup

Teacher As Peer

A few examples of teacher support revealed the teacher acting as a peer (105 [4%]). The following conversation occurred with group three:

PR: Okay now, the other part of our problem, how many tails are we supposed to have?

Adriana: (pause) 1--we're supposed to have four.

Mia: 1 2 3

PR: Oh no--what can we do? We're supposed to have four tails--we only have three! Hmm.

Another time, a student suggested counting the classroom chairs. The teacher replied, “Okay now sometimes when I count, I might count something more than once. How could I make sure I don’t count something more than once? Anybody know?”

Lead Through Puzzlement

Leading students through puzzlement was another example of teacher support found in a few utterances (103 [3%]). Aaron suggested, “If you can count just one, maybe there’s just one in there”, referring to how many objects were inside the mystery bag. The teacher answered, “You think there might be just one more. Well, let's listen (shakes sack; many cubes are heard moving around inside sack). Do you think there's one or maybe more than one?" During a small group activity, students placed zoo animals in a series of four cages based on spatial clues. After hearing the clue "The gorilla and tiger fight if they're next to each other", the following conversation occurred:

PR:	Okay so Kristina put the gorilla and the tiger next to each other. Do you guys agree or disagree?
Javier:	Oh I agree.
Steven:	I agree.
PR:	You agree? Well, listen to what happened. The tiger ate the gorilla.
Students:	Oooooh-aaaaah!
PR:	Ohhh, okay. What did our clue say? The tiger and the gorilla--oh so why did you -mix ma--switch that, Kristina?
Kristina:	Because the tiger would eat that.

<u>Informal Use of Vocabulary</u>

A few examples of teacher support included the informal use of math vocabulary (96 [3%]). The following conversation occurred while a small group identified which geometric shape would hold the most.

PR:	What shape do you want to compare it to, Kara? (sound of sand pouring)
Kara:	Um um
PR:	Okay she has the hexagon shape.

During a whole group activity, the teacher introduced the activity by stating, “So today we're going to solve a problem. Now, I don't want you to tell me the answer but I want you guys to think about. We need to get to 10 teddy bears in our jar. What's a way we could figure out how many more we need? How could we do that? What strategy could we use?”

Tools

The use of tools was found in a few examples of classroom discourse (46 [2%]). Tools were typically manipulatives used to solve problems.   After some students identified Kristina’s objects as the longest, a few others disagreed. The teacher asked, “Is there any way we could find out for sure?” When no one replied, she stated, “What could we do? Well, I just happen to have a few more things. Should I put the rest of my tools out to get us thinking?” as she placed a tub of Unifix cubes, paper clips, and rulers on the carpet. Another example occurred in a small group format as students identified how many cookies were eaten.

PR:	How could we figure out how many cookies altogether? Justin, what could we do?
Justin:	Um if the green table--
PR:	Okay. Why don't I put some tools out here that some of the other groups used. I've got these with me today . . . They were using these to solve their problem. How could we use these little squares to figure out how many total cookies we have? Javier?

Finding 7: The majority of social norms found in the classroom discourse emphasized shared decision-making (1066 [50%]). Some of the norms were related

to sharing ideas (618 [29%]). A small amount of the norms referred to problems (308 [14%]). A few utterances reflected old norms (81 [4%]) and conflict (48 [2%]).

A review of the social norms reflected in the classroom discourse emphasized shared decision-making (1066 [50%]). Some of the utterances referred to sharing ideas (618 [29%]). Discourse related to problems was found in a small amount of talk (308 [15%]). A few utterances describing old norms (81 [4%]) and conflict (48 [2%]) were found. Table 4.6 presents the research findings.

Table 4.6 Social Norms

Descriptor	Number of utterances
SUMMARY	2121
Shared decision-making	1066 [50%]
Ideas	618 [29%]
Problems	308 [15%]
Old Norms	81 [4%]
Conflict	48 [2%]

<u>Shared Decision-Making</u>

The majority of social norms found in the discourse reflected shared-decision making (1066 [50%]). Some of the utterances emphasized the group, not the teacher, making decisions (281 [26%]). After a small group solved a problem, Justin volunteered to draw the findings. The teacher stated, "You guys tell him, what do you want him to draw?" During another episode, the teacher asked, "Okay. Now how are we going to count how many cookies there are? Do you guys have a plan?" After students shared ideas for identifying the total number of eyes in the classroom, the teacher asked, "Which idea shall we try out?"

Other types of shared-decision making included agreements and disagreements (251 [24%]). While ordering the animals from the lightest to the heaviest, the teacher stated, "Okay. Let's review our order. Do you guys agree? It goes mouse, duck, monkey, tiger, bear, elephant." Another episode occurred in a whole group lesson as students identified the odd one out. Chris stated, "I agree with Kara—it doesn't measure" while touching a scale. At times, students shared their agreements and disagreements with the class using a "thumbs up" gesture to agree or a "thumbs down" gesture to disagree (48). During one lesson, the class identified that there were eight feet altogether. When asked "How many more feet do we need to come up with?" to make a set of 10, the following dialogue occurred.

Aaron:	8, 9, 10.
PR:	So how many would that be?
Kara:	Two.
	(ACTIVITY) Aaron shows three fingers.
PR:	Aaron says we need three more feet. Do you guys agree (shows thumb up) or disagree (thumb down)?
	(ACTIVITY) Several students show thumbs down [Tiara, Kara, Alex]; a few--thumbs up [Javier, Ivan]

Some utterances related to shared decision-making included the question "What do you think?" (179 [17%]). During a whole group lesson, the teacher asked, "Colby, what do you think?" During a small group activity, the teacher asked, "Ivan, what do you think we need to do?"

Teamwork was emphasized in some of the utterances related to shared-decision making (163 [15%]). While working with group four to solve a problem, the teacher stated, ". . . Remember we're working as a team to solve this problem. Chris? Aaron? You need to be helping Colby. She's your teammate." Another time during a whole group activity, the teacher asked students to identify how many counters were in the jar. When students did not respond, she stated, "Talk to your teammates. They'll help you remember."

Some of the shared-decision making included the question "What could we do?" (74 [7%]). After a conflict arose in the classroom as to which object was the longest, the teacher asked, "What could we do to really solve this measurement mystery and know for sure if Chris and Steven and Javier's idea's right?" During a small group activity, the teacher stated, "I started with 10. And I know I have seven left over. What could we do to solve this problem?"

Voting was found in some utterances related to shared-decision making (70 [7%]). In small groups, the teacher stated, "Then next week we're going to vote as a class on which idea we want to do." After students suggested ideas to solve a problem, the teacher stated, "Okay, let's take a vote. Who would like to do the cubes on the floor in front of us like we did last time?" A few students mentioned voting in their ideas (5). After Kara suggested making a list of party ideas, she continued, "And um and then who wants to vote and then you and then I um if someone if you say like who wants like a pizza par, a pizza party, they'll raise" their hand.

Some of the utterances related to shared decision-making was talk about making decisions (34 [3%]). During a whole group activity, the teacher stated, “Some of you’ve been giving ideas and maybe answers and . . . some of you have been disagreeing. Now if I disagree with an answer, does that mean I say, no that’s a dumb idea?” During another activity, the teacher shared, “Okay so if you don't agree with someone's idea, you could say ‘that's a good idea maybe we could try something different?’ So could we be kind if we disagreed?”

A few utterances related to shared decision-making involved making choices (14 [1%]). While working with group two, the teacher stated, “. . . Now if you want, you can do it by yourself or you can work together with a partner. You decide.” Another example took place as group one represented the number of students in the classroom. The teacher suggested, “Whatever you think to show your number.”

<u>Ideas</u>

The findings indicate that some of the classroom norms reflected in the discourse referred to sharing ideas (618 [29%]. Some of the utterances identified talking norms as student shared and discussed their ideas (127 [21%]). After a small group solved a problem, the students were asked to draw the results. The teacher asked, “ Have you figured out what you’re gonna do? Talk to Aaron. What do you want him to do . . . ?” After Adriana disagreed with Mia’s answer, the teacher stated, “Oh Adriana says no. Adriana, you wanna go talk it out with her?” During the final lesson of the research project, the students were asked if it was hard to solve problems. Steven replied, “It’s easy because all you have to do is just talk about it and figure it out.”

Some of the discourse referred to showing or representing ideas (119 [19%]). After noting that Megan had 10 green cubes stuck together and a piece of paper with a drawing of 10 cubes, the teacher asked, "Okay Megan, show me what you've just done." After group two solved a problem, the teacher asked, "How can we show the answer to this problem?" After groups identified ways to make sure everyone has a turn, the teacher stated, "Okay. So we've got crayons and pencils and I want you guys to draw a picture of what your idea looks like."

Some discourse emphasized having different ideas (101 [16%]). During a whole group activity, the teacher asked, "Do you have a different way we could figure out how many eyes we have in our classroom?" After Colby shared her idea, the teacher replied, "So you like Kara's idea of using tally marks and then sitting down. Anybody have a different idea?"

A small amount of talk referred to understanding others' ideas (77 [12%]). After Mia shared her idea, the teacher asked, "Okay . . . do you guys understand or do you want Mia to explain it again?" During another activity, Michael suggested a way to solve a problem. The teacher replied, "Aaron, you look like you don't understand something. Ask Michael. What do you not understand?" During a whole group activity, the teacher suggested, "If someone is talking and you don't understand them, maybe you could raise a quiet hand and say, 'Todd, I don't know what you mean. Can you tell me it in a different way'?" After Tiara shared that she liked Michael's ideas, the teacher replied, "So when you hear someone talking, they're sharing their thinking. So that help them—help us understand and make our ideas better."

A small amount of discourse related to building ideas was also found (76 [12%]). After Javier shared a way to solve a problem, the teacher replied, “So Javier started an idea. We could put two of the cubes on. Anybody have an idea we could add to Javier’s . . . ?” During a whole group activity, the teacher shared:

> Adriana and Madison were at the calendar. They noticed that the number 21 was missing so together they talked out how to come up with an idea to solve the problem. It wasn’t just Adriana’s idea and it wasn’t just Madison’s idea. It was both ideas put together.

After Kara shared an idea that hadn’t worked before, the teacher replied, “but could we still take part of Kara’s idea? Make a list of ideas and then what could we do to make sure people all vote? Think about Kara. She started our idea. Who can stack another idea on top of it?” After Alex shared an idea for making sure everyone has a turn in class, Chris suggested, “Um we can use Alex's idea and you can put cubes on um [pause] names and [pause]whoever doesn't have a cube on their name, they getta have a turn.”

A few utterances referred to thinking about ideas (59 [10%]). When asked if it helped to hear people share their ideas, Chris replied, “Because um so we can know how it how you um (moves finger around in circle next to his ear) thought--how you--so you'll know what um um idea is.” After a student shared an idea for identifying the most popular lunch food, the teacher shared, “Okay, so let’s think back, let’s think that through.” After Kristina paused and did not reply when called on, the teacher stated, “Okay, I’m gonna come back to Kristina. She’s still thinking.” After Steven disagreed with Kara’s idea, the teacher replied, “Steven, go ahead and tell us what you’re thinking.”

The question “Anybody have an idea?” was found in a few utterances related to ideas (36 [6%]). During one activity, the teacher asked, “I wonder how many noses we would have in our class if we had a party? Anybody have an idea about how we could find out?”

Listening to others’ ideas was found in a few examples of classroom discourse (23 [4%]). During one whole group lesson, the teacher stated, “Well, another thing we talked about is . . . how to show people you’re listening.” When a student interrupted, the teacher replied, “Oh I’m listening to Megan. She says put sand in here and see if it equals to go in here?”

Problems

Talk related to problems was found in some of the classroom discourse (308 [15%]). Some of the talk was about problem-solving (117 [38%]). During a whole group lesson, the teacher began by stating, “Okay guys here we are. We are problem-solvers again today.” While introducing the class to the research project, the teacher stated ,“For the rest of the year, we are going to be problem solvers in our classroom.” She later explained, “Now a problem . . . is something that we don’t know how to solve right away . . . We have to use our brains to figure out different ways to solve it.” During the last day of research, the teacher invited students to share what they had learned. After Kristina suggested, “Maybe you can solve problems in music and stuff”, the teacher replied, “So we don’t have to just solve problems at one time of the day, we can solve them all day long.”

Some of the talk related to problems included the words “investigate/figure out” (102 [33%]). After students made a prediction about which geometric shape would hold the most, the teacher stated, “Okay so we have a prediction. Does anybody have a way we could figure out for sure that this one really holds the most?” After a group identified what was inside the mystery bag, the teacher replied, “. . . Would you like to write the results of our investigation?”

Other talk referred to problems being good, tricky, or exciting (51 [17%]). While working with small groups, the teacher stated, “Yesterday, we solved a yummy problem. We had to figure out if Mrs. Bequette had enough cookies.” After students earned 10 counters for a class party, the teacher explained, “Now here’s our really good problem today. Sometimes problems are extra good . . .” Another time, the teacher stated, “Okay problem solvers . . . I have probably the most exciting problem for us to solve today.”

A few utterances referred to real-life problems that occurred in the classroom (28 [9%]). “Well, . . . we’ve been talking about this problem all week because we've been talking about insects. Now-- Jamie had an idea the other day. He wanted to write about a spider in the tall, tall grass but we weren't sure if a spider was an insect or not. Now some of you might think you know but I want to ask us as problem solvers, how could we find out?” Another example took place in a small group:

PR:	Kristina hasn't had a turn but we don't get a turn by throwing things.
Javier:	Oh I know what we can do--we can take turns pouring
PR:	Okay, so who should go next?
Javier:	Um (pause) how about like Kristina, Jamie, Steven.
PR:	Okay, so hold the cube. Which shape are you gonna pour it into?

A few utterances referred to mistakes (10 [3%]). “ 1, 2, 3, 4, 5, 6, 7, 8, 9, 10. Oh Mrs. Bequette goofed up. How many counters are in our jar?” After voting on the students’ favorite strategy to use, the teacher stated, “6, 7. Let me try it again. 1, 2, 3, 4, 5, 6, 7, 8, 9.” After Kara shared that there were six items inside the mystery bag, Alvin stated ,“Well, I was wrong because I was about to say five.”

<u>Old Norms</u>

Old norms were found in a few examples of classroom discourse (81 [4%]). Much of the old norms included student praise given by the teacher (59). After the class identified there were 22 noses in the classroom, the teacher replied, “Awesome problem solving today. Way to go.” When Kristina suggested, “Maybe you can solve problems in music and stuff”, the teacher stated, “Very good. So we don't have to just solve problems at one time of the day, we can solve them all day long.”

Some of the old norms referred to ownership of ideas (8). After Tiara shared an idea for figuring out which geometric shape held the most, Megan stated, “That’s my idea!” Aaron replied, “I came up with it” after the teacher invited another student to locate the picture of the pig.

Other examples had to do with old expectations (6). During week one of the research project, the following conversation occurred:

PR:	I want you guys to help me think of some rules we could have in our classroom when we meet on the carpet to solve problems. What would be something we'd want to do if someone was talking?
Kara:	Give them the quiet signal.

PR: Okay. So we can give them the quiet signal but they're talking. We want them to be able to talk. So what should you be doing if they're talking?

Aaron: Ignore them.

A few examples reveal the teacher self-correcting her speech (4). After a small group had solved a problem, the teacher stated, “Well, I need your group to draw a picture of your answer. And you know what, I’m gonna let—why don’t you guys decide?” After Jamie suggested filling the shapes with sand, the teacher replied, “So do you wanna—what do you want to do with that one then?”

Other times, the teacher provided too much support by inadvertently solving the problem for the students by offering suggestions (4). After Kara suggested using tally marks, the teacher suggested, “So we could put tally marks. Now here's something tricky. What if by mistake Marissa comes up twice. How could we not have that happen?” During a small group activity, the teacher stated, “We're gonna go into the classroom and we're going to investigate how many chairs we have in our classroom. Now here's something tricky. How could you keep track of how many chairs we have? What could you do, Marissa?”

<u>Conflict</u>

A few utterances emphasized conflict (48 [2%]). Much of the conflict-related talk dealt with issues of fairness (23 [47.9%]). While sharing ideas on how to fairly divide a box of cookies, Kristina suggested, “If there's not enough, you can you could pick them up and give one.” The teacher replied, “Oh, so if there's not enough . . . we could pick them back up to make us fair? Does that sound fair to you guys?" After Kara shared an idea for making sure everyone gets a turn, Steven stated, "um, that won't be fair."

Friendship was referred to in a few utterances (14 [29.2%]). When asked what it means to solve a problem, Megan stated, " Like if somebody's bothering if somebody's bothering uh somebody else in the classroom, um you can say guys, maybe you guys can be friends." On the last day of the research, students shared what they had learned throughout the project. Kristina shared, "Um if there's fighting, if two persons are fighting, um they could –fighting and we could work together." The teacher stated, "You have to talk it out so when we talk out problems for math, we can also talk out problems when someone's not being our friend. And so when we solve problems does that help us be better friends? 'Cause everybody gets in arguments and disagrees don't they. We can still be friends."

A few examples of classroom discourse referred to puzzlement (11 [22.9%]). While trying to identify what was in the creepy crawlie jar, Chris stated, "I think this one is too hard." During a whole group lesson, students were having difficulty figuring out how many objects were in the mystery bag. The teacher stated, "What if, okay, it looks like we're kinda stumped. So I'm gonna put a tool out here. I wonder if we could use this tool to help us solve this problem?" After Kara identified that 4 + 4 = 7, Chris, Aaron, and Steven displayed four fingers on each hand. After several seconds, Steven leaned over and whispered, "It's eight" in Kara's ear.

Chapter Summary

This chapter presented the seven findings revealed through an examination of Kindergarten students' exploratory math talk. The findings were organized according to the initial research questions. Data drawn from whole group, small group, and observations were shared to provide understanding of the phenomena under study. A significant portion of the chapter utilized samples of participants' discourse. This was done to build confidence in the reader that every effort was taken to accurately represent the participants' perceptions through their own words.

CHAPTER V

CONCLUSION

INTRODUCTION

The research purpose was to examine what is revealed in Kindergarten students' exploratory math talk. In addition, classroom discourse was analyzed to provide an understanding of the social context affecting the research. Seven conclusions are included in this chapter. The conclusions will follow the research questions and the findings, thus addressing the following areas: (1) What mathematical concepts are present in students' exploratory talk?, (2) What does exploratory talk sound like in Kindergarten students?, (3) What accompanies exploratory talk?, (4) When do students engage in exploratory talk?, (5) In what ways are students supported in their math talk?, and (6) How are social norms reflected in math conversations? As the nature of qualitative research is to promote understanding, the final three research questions are interwoven into one conclusion to provide a more holistic view of the phenomena. Additionally, supporting vignettes from the research will be shared along with research and theory to draw the reader into the inductive process. A summary of the conclusions will be provided followed by recommendations and a final reflection. As an ethical researcher, I acknowledge that these conclusions are my best interpretations.

What Mathematical Concepts Are Present?

An examination of the findings indicates that the majority of the math-related talk emphasized number and operations. Number was also found in the participants' problem-solving ideas. Other concepts were identified to a much smaller extent, including measurement, data analysis, geometry, and algebra. Exploratory talk related to number and operations had the largest number of errors.

There are two primary conclusions that can be drawn from this finding. First, the mathematical concepts found in students' exploratory math talk included, to a large extent, number and operations. Other concepts such as measurement, data analysis, geometry and algebra were found to a lesser degree. As students shared exploratory math talk, their mathematical thinking was revealed which included errors, misunderstandings, and misperceptions. As a teacher, these insights can guide the type of activities and lessons offered to support their mathematical growth. Additionally, a second conclusion can be drawn that indicates students generally rely on their understanding of number to solve problems. This conclusion is supported by the research findings, namely: (1) the majority of exploratory math talk was about number; (2) participants shared problem-solving strategies related to number; (3) more errors were found in exploratory talk related to number and operations; and (4) some students utilized their understanding of number to solve problems related to other mathematical concepts. Each of these areas will be addressed in the next section.

<u>The Majority of Exploratory Math Talk Was About Number</u>

The findings indicate that the majority of exploratory math talk was related to number concepts, including object counting, verbal counting, adding and taking away, and number comparison. As students discussed and solved problems with their peers, much of their exploratory talk included counting, number comparisons, and other discourse related to number. One might conclude, based on this finding, that students rely on their understanding of number to solve problems. NCTM (2000) finds that young children's earliest reasonings are about number situations. Their first representations typically include numbers. Children's development of number begins during infancy and is supported by their early experiences (Clements, 2004). Baroody (2004b) notes that much of a child's daily life revolves around number. As children engage in a variety of everyday activities that involve number, they are developing "a considerable body of informal knowledge" (Baroody & Wilkins, 1999, p. 49). Siegler (1996) finds that these early understandings of number are often utilized to solve problems, much of which is not taught in the formal sense. This is not surprising according to Piaget's constructivist theory because children construct an understanding of number internally through their interactions with the environment. Kamii (2000a) writes:

> From a Piagetian perspective . . . it is clear that since the source of logico-mathematical knowledge is inside the child, children can be expected to construct number concepts and invent arithmetic through constructive abstraction. Historically, our ancestors invented arithmetic to solve practical problems, such as keeping track of sheep and figuring out when to plant seeds. Therefore, young children, too, can be expected to invent arithmetic out of everyday living (p. 66).

As young children construct an understanding of number, they are able to invent ways to solve problems. Vignette 1 describes the exploratory math talk of a student who utilized his everyday knowledge to informally solve a difficult problem using number.

Vignette 1: How Many Cookies?

Twenty Kindergarten students worked together to identify the number of cookies each student would receive while enjoying a special snack. The students determined that each student could have two cookies with one leftover for the teacher. The next day, while working with small groups, the teacher posed the question, "I wonder how many cookies were eaten?"

After several students shared ideas for solving the problem, Chris raised his hand, sharing his answer of "Forty-one." After students worked together to solve the problem, Chris was asked to explain how he found the answer. He announced, "I counted to 20 and then and then I counted to 20 again and then I counted one and then (pause) I came up. And yesterday I counted to 20 and counted to 20 and that makes 40 and I counted one more and added up to make 41."

<u>What I Learned</u>

Enjoying a snack together is an everyday activity in many early childhood classrooms. Young children typically count the number of snack items they receive (NCTM, 2000). The teacher builds on this natural curiosity, asking them to solve a complex problem from everyday life in the classroom. No one had formally taught Chris to determine the answer by counting. He invented a mental counting strategy, utilizing his informal knowledge of counting to solve a complex problem.

<u>Participants Shared Problem-Solving Strategies Related to Number</u>

Additionally, many participants shared problem-solving strategies that were related to number, with the majority of participants referring to object counting in their talk. This finding supports the conclusion that students may rely on their understanding of number to solve problems. Schifter (2005) writes that "individuals necessarily approach novel situations by interpreting them in the light of their own established structures of understanding" (p. 85). Kindergarten students have had varied opportunities to construct an understanding of number. One might speculate that students would utilize this knowledge when asked to solve problems. In particular, many of them might suggest ways that are connected to one of the big ideas of mathematics, namely counting (Baroody, 2004b).

Research suggests that counting is the foundation for children's early number development (NCTM, 2000). "Young children are motivated to count everything from the treats they eat to the stairs they climb, and through their repeated experience with the counting process, they learn many fundamental number concepts" (p. 79). Counting objects involves identifying how many items are in a group (Clements, 2004). Baroody (2004b) suggests that object-counting is based on the principle of cardinality. Cardinality refers to the understanding that the last number stated when counting objects identifies the number of objects. Vignette 2 illustrates how Kindergarten students shared problem-solving strategies that drew on the big idea of object counting.

Vignette 2: Let's Count . . .

In preparation for an upcoming Valentine's day party, students were asked what they could do to make sure there were enough chairs for everyone who attended. The following dialogue portrays students' problem-solving strategies involving object counting.

Megan: I can count how much people are in the classroom.

Madison: We can go down and count the names.

Kara: You could count the artwork that we have.

What I Learned

The teacher related the problem to a real classroom situation, using students' excitement about an upcoming party to fuel their investigations. While students are not demonstrating the concept, they recognize that counting objects could solve the problem. All three students connected counting with the number of chairs needed. This suggests an understanding of cardinality as Megan, Madison, and Kara recognized that the number identified should equal the number of chairs needed.

The Majority of Errors Were Found In Number-Related Exploratory Math Talk

The findings indicate that the majority of errors found in students' exploratory math talk were related to number, including adding and taking away as well as object counting. One might conclude that when young children draw on their early number sense to solve problems, errors may result. "Undeveloped ideas and misconceptions are a normal part of the child's evolving understanding" (Richardson, 2004, p. 323). Kamii (1982) suggests that when students make errors, it is often " because they are using their intelligence in their own way" (p. 41). She continues that a teacher's role is not to correct the child but to determine how the error was made. Fosnot and Perry (2005) agree, concluding that errors "need to be conceived as a result of learners' conceptions, and therefore not minimized or avoided" (p. 34).

Many of the errors found in students' exploratory math talk were related to adding and taking away. Kamii (2000a) writes that addition is "the mental action of combining two wholes to create a higher-order whole in which the two previous wholes become two parts" (p. 67). She concludes that part-whole relationship can be difficult for young children as they may have difficulty "thinking about the whole and the parts at the same time" (p. 11). When students add numbers, they must put two wholes together to create a new whole. The previous wholes then become two parts (Kamii, 2000b). The research suggests that participants had difficulty with counting on. Kamii (2000a) maintains that counting on can be difficult for young children because of difficulty with part-whole relationships. She concludes that counting on should not be formally taught as students will construct the understanding on their own. Rather, opportunities should be given that encourage students "to think flexibly about numbers and construct a network of numerical relationships (p. 69).

Some of the errors were related to object counting. Piaget (1965) found that number requires an understanding of two relationships, namely order and hierarchical inclusion. Order refers to the understanding that objects must be placed in an order, either literally or mentally, so that an object is not overlooked or counted more than once (Kamii, 1982). Hierarchical inclusion refers to an understanding that within a set of objects, *one* is part of *two, two* is part of *three*, and so forth. While counting 10 objects, children without this understanding will typically point to the tenth object when asked, "Show me 10." Vignette 3 details two examples of errors found in the exploratory math talk related to number.

Vignette 3: Number Concept Errors

Students worked together to identify how many more counters were needed to make a set of 10 when beginning with seven. After students had an opportunity to work with a partner to determine the answer, students met together to share their results.

Steven: Um, I found out with four because we need four more.

PR: Okay so Steven says we need four more. Steven, how did you come up with that number?

Steven: 'Cause I counted with my fingers (shows fingers, one at a time) 7, 8, 9, 10.

Another day, Justin counted a set of 10 objects, stating "1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11."

What I Learned

The problem was related to the context of the classroom as students had earned seven counters. They needed 10 counters to have a classroom party. Rather than tell the students how many more counters were needed, the teacher posed the problem to the class. One possible explanation for Steven's error is that he had not constructed an understanding of part-whole relationships necessary for counting on (Kamii, 2000b). Justin's counting error suggests that he has not constructed an understanding of order as he counted one object twice (Kamii, 1982).

Students Used Number To Solve Problems Related to Other Mathematical Concepts

The findings reveal that number was also found in the students' exploratory math talk related to other mathematical concepts. This suggests that students' rely on their understanding of number as they solve problems, even problems related to other mathematical concepts. Number is traditionally viewed as the "cornerstone" (NCTM, 2000, p. 32) of mathematics. As students develop a deep understanding of counting, numbers, and computation, they are able to apply these to other mathematical concepts such as measurement, geometry, and data analysis. Vignette 4 illustrates how three students used their understanding of number to solve a measurement-related problem.

Vignette 4: Feed the Zoo Animals

A measurement task was given to a small group of students. They were asked to order a series of animal picture cards from the lightest to the heaviest to prepare the animals for feeding. The following conversation occurred as students worked together.

Todd: The the mouse weighs um like one pound

Aaron: And the monkey and duck weigh like three pounds

Chris: No the monkey is like six pounds

Todd: Ooh

Chris: Tiger is like 10 pounds.

Todd: Tiger is not 10 pounds it weighs more!

Chris: I think the tiger weighs like 20 pounds.

What I Learned

Each of the animal cards were the same size. Students had to draw on their prior knowledge as they ordered the animals from lightest to heaviest. Students were not instructed to use number to order the animals. This group created their own strategy drawing on their understanding of number to place the animals in sequential order.

At times, students' use of number to solve problems related to other mathematical concepts led to errors as Vignette 5 illustrates.

Vignette 5: Measurement Mystery

One afternoon, students were presented with a *Measurement Mystery:*

Max, Kristina, and Javier were measuring objects in the classroom. These are their results:

Max's object = 5 rulers

Javier's object = 10 large paper clips

Kristina's object= 15 Unifix cubes

When asked which object was the longest, Madison suggested that Kristina's object was, explaining "Um it—because Javier had 10 and Kristina's was bigger than that—she had more."

What I Learned

It would seem that Madison used what she knew about number to make a prediction. However, her centration on the quantity of objects caused her to have an error as she did not take into consideration the size of the objects. Kara made the same error, stating "Uh I think she's right." Later on in the lesson, she corrected her initial response, recognizing that five rulers placed in a line would be longer than 15 Unifix cubes.

What Does Exploratory Talk Sound Like In Kindergarten Students? (Part One)

The findings indicate that the overwhelming majority of participants had speech disfluencies in their exploratory talk. These included "um", pauses, abbreviations, repetition, "like", "uh" as well as false starts and overlapping speech. A conclusion that can be drawn from this finding is that when students engage in exploratory talk, they are forming ideas while talking, resulting in utterances that are not well articulated. Barnes (1992) referred to this type of speech as similar to the first stage of writing. "Exploratory talk is hesitant and incomplete because it enables the speaker to try out ideas, to hear how they sound, to see what others make of them, to arrange information and ideas into different patterns" (Barnes, 2008, p. 5). Cazden (2001) suggests that such talk indicates "cognitive load" (p. 170) as students struggle to think out loud. She continues that through exploratory talk, students' explanations can become more complete as they interact with peers and the teacher. Vignette 6 describes a participant's exploratory talk, ripe with speech disfluencies, that becomes clearer when restated.

Vignette 6: Speech Disfluencies

During a whole group activity, students shared strategies for determining how many cookies were eaten the day before.

Madison: Uum we can um see um that um how many cookies that were in the box and if we and iihh if we just forgot if we just forgot how to, we could take them out and then put them on the plate and then if um if that's enough and when you tell us to stop, that means that's how many cookies there was.

PR: Okay. So did you understand what Madison said? Does someone want to ask her a question? Megan?

Megan: Um what did you say?

PR: Can you say it in a different way?

Madison: Um I said we could put them by groups um down and then um um when you tell us to stop, we could stop and figure out how many we have.

<u>What I Learned</u>

Madison's exploratory talk is full of speech disfluencies, including "um" and repetition, making her idea difficult to understand. The teacher, rather than asking Madison to repeat her idea, engaged the class in determining if they understood her response. While her second response still has a few speech disfluencies, she seems to have a better understanding of her idea and is able to articulate it more clearly.

<u>What Does Exploratory Talk Sound Like In Kindergarten Students? (Part Two)</u>

The study's third major finding was that all participants shared ideas through their exploratory talk. Many offered statements for joint consideration, challenged others' ideas, shared hypotheses, made requests for clarity, and had joint agreements in their talk. Some students used evidence to support their thinking, drew conclusions, provided alternate theories, and made revisions in their thinking.

One conclusion that can be drawn is that exploratory talk sounds like students exchanging ideas. Through these exchanges, students are sharing their perspectives that may be challenged by others. This can lead to an ongoing refinement of ideas. Piaget (1950) found that when students exchange ideas with their peers, their logic may develop. Young children are typically egocentric, meaning they think from one point of view—namely their own. However, as students share ideas with one other, they must take others' perspectives into account in order to make their own idea understood. Perret-Clermont (1980) and Doise-Mugny (1984) found that when students have opportunities to agree, disagree, and convince each other, they demonstrated higher-level thinking. While peers are not a source of logico-mathematical knowledge, students may reexamine their own thinking as a result of confrontation with others' points of view (Bell, Grossen, & Perret-Clermont, 1985).

In applying these theories to this study's research findings, a view of exploratory talk is revealed that is cyclical in nature. A student begins by sharing an idea, offering a statement for joint consideration, or suggesting a hypothesis. Peers may then challenge the idea, agree or disagree, or ask for clarity. The student may, as a result of the interaction, clarify the original idea. Evidence may be offered in support of the idea or the student may defend the idea, challenging the peers' opposition. The dialogue may continue, moving back and forth as ideas are offered, built upon, challenged, or supported. This may result in a student drawing conclusions, making revisions in thinking, or offering alternate theories—all of which may impact future exchanges. The teacher may enter into the dialogue at any point while being cognizant of the inequality of power so as not to override or stifle student responses (Barnes, 1982). Figure 5.1 provides an overview of the exploratory talk cycle that I derived through analysis of the discourse as illustrated in Vignette 7.

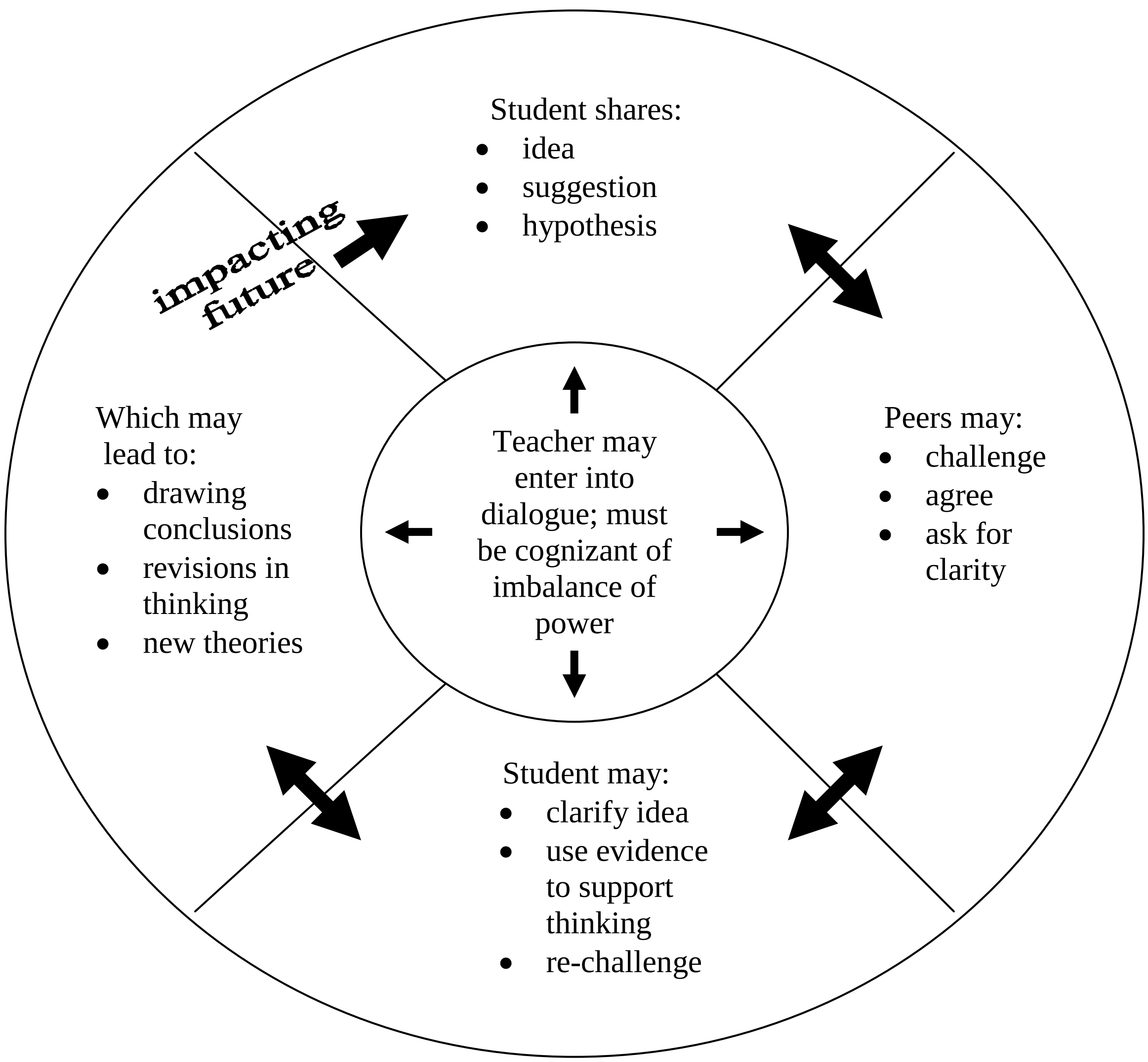

Figure 5.1 Exploratory Talk Cycle

Vignette 7: Exploratory Talk Cycle

While working in a small group, students were shown five geometric shapes and asked to figure out which shape would hold the most. The following conversation began:

Javier: Um I think it should be the biggest one

PR: Okay. How can you tell which is the biggest since they're all different shapes?

Javier: This one

PR: So Javier predicts the cube is the biggest. Do you guys agree or disagree? Is the cube gonna hold the most?
Kristina says she disagrees. Why do you disagree?

Kristina: ‘Cause this one it's like longer and taller

Javier: No this one
They're both the same size

Kristina: No, mine's longer.

Javier: No, I think these ones are the same size
She wants those to hold more

Kristina: Because this one has-is so long um its long and even cans are.

PR: Okay so it's kind of like the shape of a can? Well, I hear some arguing--you guys aren't real sure. How could we figure out which one holds the most?
I brought a tool that we could use. Anybody have an idea for how we could use our tool? Jamie, what do you think we could do?

Jamie: We could um (pause) see which one holds the mostest with the sand.

A short while later, the students took turns pouring sand into the various containers.

PR: Okay. Now is it full?

Javier: Yes!

PR: If we think the cube holds more sand than this--um rectangular prism, what will happen? Javier, what do you think will happen when we pour the sand into here?

Javier: Like sand will be um ca-there's more sand in there ‘cause this one is the size of that one. I think there--they should hold the same size.

PR: Okay . . . Let's find out.

(sound of sand pouring into container)

PR: What do we notice?

Which one held the most sand?

Javier: This one

PR: Why does the cube hold the most sand, Javier?

Javier: There wasn't there wasn't en- ‘cause all of it didn't go in there!

PR: Oh there's still some left?/Javier: Yes ‘cause it wasn't the same--I thought it was. But it wasn't.

<u>What I Learned</u>

Javier began the exploratory talk cycle by sharing a hypotheses. Kristina challenged Javier’s idea, suggesting hers was “longer and taller.” Javier began to defend his idea but ended up modifying his original stance that the cube held the most, stating, “They're both the same size.” Kristina again challenged Javier’s idea. Javier defended his response, sharing what he believes Kristina’s perspective is when he states “She wants those to hold more." Kristina defended her answer, using evidence based on prior knowledge when she relates the shape of her object to a can. A shift in the dialogue is viewed when Jamie introduced a new line of thinking, suggesting that sand be placed in each object to determine which object holds the most. Later on, Javier again offered a hypotheses, believing that the two shapes would hold the same amount. After his hypotheses is tested, Javier revised his thinking, concluding, "Yes 'cause it wasn't the same--I thought it was. But it wasn't."

What Accompanies Exploratory Talk?

The majority of participants used hand movements as they shared exploratory talk. These included gestures such as pointing to objects and dramatization of part of their speech. Some participants used their fingers as they solved problems.

Gestures

One conclusion that can be drawn from this finding is that gestures may be a way that students fill in the gaps between their mathematical ability and verbalization. The students in this study used gestures to add meaning to their math talk. Schwartz and Brown (1995) found that young children in particular have difficulty explaining their mathematical thinking. Gestures are one way people communicate ideas (NCTM, 2000). They can be defined as a type of non-verbal communication made with our hands (Goldin-Meadow, 2003). Gestures are typically different from other forms of hand movements in that they are constructed at the moment of speaking. Goldin-Meadow suggests that gestures can reflect thoughts which are not always revealed through words as described in Vignette 8.

Vignette 8: Exploratory Talk Gestures

One day, students were asked to share ideas to determine what kind of classroom party they should have. Megan suggested, “We um we can grab a piece of—a square paper and write down our favorite food” as she moved her finger across the carpet. While solving the *Measurement Mystery*, Madison suggested “Um we um can put out some cubes (points to cubes) next to that” as she pointed to a ruler.

What I Learned

The first example, according to Goldin-Meadow (2003), represents an iconic gesture, meaning it bears a close relationship to the context of speech. Megan is talking about writing down favorite foods as she moves her finger across the carpet to represent writing. Madison’s use of pointing is a deictic gesture in which the speaker points to a real object, namely a cube and a ruler (Goldin-Meadow, 2003). This adds meaning to her speech, allowing others to have a better understanding of her mathematical idea.

Use of Fingers To Solve Problems

Another conclusion that can be drawn is that students utilize their fingers as a representation of their mathematical thinking. Kamii (2000a) found that students prefer fingers over counters. She writes “fingers are symbols used in the service of thinking” (p. 29). Piaget (Kamii, 2000a) distinguished between signs and symbols. Signs are considered a type of social knowledge and cannot be constructed by the child. Symbols, however, represent the child’s thinking and are invented by the child. Vignette 9 illustrates a student’s use of fingers to solve a problem.

Vignette 9: Use of Fingers To Solve Problems

During a math activity, students worked at tables to determine how many more counters were needed to make a set of 10 when beginning with seven. Following the activity, students would bring their findings to the class for consensus. As the students worked, the teacher visited with individuals and partnerships. Students were provided with access to counters and paper. The following conversation occurred:

PR: Okay . . . have you figured out how many more counters we need for our party?

(ACTIVITY) Javier nods head.

PR: Show me that answer.

Javier: Ten more.

PR: Do we need 10 more?

(ACTIVITY) Javier looks down then shows three fingers.

Javier Three! Yeah three!

PR: Okay, show me how you came to that answer.

What I Learned

Javier originally gave an incorrect response (10). When the teacher restated his answer, he employed his fingers as a tool for thought, showing three fingers. He was then able to voice the correct response, "Three."

When Do Students Engage In Exploratory Talk?

The remaining three findings were drawn together for the final conclusion. Apart, they seemed to offer only a simplistic view of the study similar to pieces of a puzzle. Together, they portray a more complete understanding of the phenomena. A summary of each finding is provided as well as concluding remarks and supporting statements which will result in a final conclusion for this research study.

Fifth Finding

The students in this study shared many examples of exploratory talk in both large and small groups. The observational data revealed exploratory talk during the classroom day, including calendar, math table activities, snack preparation, and a class meeting. Based on these findings, one might conclude that young children engage in exploratory talk when they have opportunities to share and exchange ideas with their peers and the teacher. Throughout the study, students were given opportunities to operate together as they exchanged viewpoints, disagreed, and negotiated. Mercer (1995) writes that "there is no evidence from research to show that anyone is incapable of exploratory talk. What is more, there is no reason to assume that the basic principles of exploratory talk are alien to children" (p. 108). However, Mercer continues that students do not necessarily know how to engage in quality talk on their own. They need guidance on how to use talk, namely through the support of a teacher.

Sixth Finding

The sixth finding revealed that much of the teacher support was the use of reply not assess words. Some of the teacher support included the revoice of students' responses and the use of open-ended questions. A small amount of teacher support included review, the teacher acting as a peer, leading students through their puzzlement, informal use of math vocabulary, and the use of tools to support thinking.

One might conclude that students were supported in their math talk by the teacher who guided the conversations by playing an active role in the inquiry process. As an inquiry guide, she was responsive to the students' talk, as she stepped in and out of the dialogue in an attempt to elicit their thinking. During whole group activities, the teacher was able to model components of quality talk, drawing out students' thinking while being respectful of their ideas. These support systems were in place, to a lesser degree, during small group activities as well. Barnes (2008) maintains that how teachers respond to students' contributions is crucial to how children confront a learning task and ultimately what they learn. "It is by the way that a teacher responds to what a pupil offers that he or she validates—or indeed fails to validate—that pupil's attempts to join in the thinking" (p. 8). In exploratory talk, students are sharing their thinking out loud which can be a daunting task even for adult learners.

<u>Seventh Finding</u>

The last finding was that the majority of social norms found in the classroom discourse emphasized shared decision-making. Some of the discourse was related to ideas, including building upon others' ideas. A small amount referred to problems, specifically solving problems as a group. A few utterances reflected old norms which demonstrated the process of change in the classroom as the students and teacher alike learned to talk and interact in new ways. Others were related to conflict, both internal and external, in which students used talk to puzzle through.

After an examination of the seventh finding, one might conclude that the social norms reflected in math conversations emphasized collaboration between the teacher and the students.   This was evidenced through the majority of utterances revealing shared decision-making. Additionally, students learned to build upon others' ideas. Talking, listening, and thinking norms changed as students and the teacher alike learned to use talk as not only a means of communication but as a way to think out loud together. Problems became something worth having. Students learned to work together through their words and actions as they strategized and solved problems. Conflicts were negotiated as students shared in the decision-making process. Creating a collaborative classroom environment takes time as evidenced by the old norms present in some of the talk. However, change was underway as evidenced by the new social norms found in examples of student talk such as when Chris suggested, “Um we can use Alex's idea and you can put cubes on um [pause] names and [pause]whoever doesn't have a cube on their name, they getta have a turn.” Barnes (1992) writes “So teacher and pupils join in setting up the social context or communication system, and it is this which will shape the range of language strategies used by pupils as they grapple with learning tasks” (p. 33).

Final Conclusion

Based on the three research findings, one conclusion that can be drawn is that young children engage in exploratory math talk when they have opportunities to exchange ideas with their peers and the teacher in a collaborative classroom environment with a teacher who acts as an inquiry guide. This process can take time as students and the teacher construct new social norms for interacting in the classroom. In such an environment, the teacher is no longer the beacon of knowledge. Rather, students are viewed as members of a mathematical society. Talking, listening, and representing ideas becomes the norm. Problems are something to be desired in such a community of learners. The end result is one of a caring community where students and the teacher alike can think out loud together about mathematics as depicted in Vignette 10.

Vignette 10: Teacher As Inquiry Guide In A Collaborative Classroom Environment

The following excerpts are drawn from whole group lesson six. Dialogue will be shared along with a discussion of the teacher support and social norms evident to guide the reader’s understanding.

	Excerpt	Discussion
PR:	Now, I wonder if there's any way I could figure out how many things are in my sack without opening the sack?	The teacher poses an open-ended question, asking students to share strategies. If the question had been closed (i.e., How many things are in my sack?), the line of inquiry would stop after the correct response was given.
PR:	Do you have an idea Todd?	The teacher asks for ideas from the students, indicating that the students' ideas are worthwhile.
Todd:	Um (pause)	Todd begins an idea using a speech disfluency.
PR:	I know there's something in here (shakes bag) and I know I have four cubes (places cubes). slightly apart on the carpet). How could I figure out how many things are in my sack?	After giving Todd time to respond, the teacher supports his thinking by reviewing the problem.
Todd:	Mhhmm	Again, Todd replies with a speech disfluency, suggesting that he is thinking about the question.
PR:	Hmmm, is that tricky?	The teacher acts as a peer by suggesting the problem is tricky.
Todd:	Yeah!	
PR:	Yeah. Pretty/Todd: Four!	While Todd does not respond to the actual question and instead shares a quantity, he is sharing his thinking.
PR:	Tricky. You think there might be four?	The teacher revoices his response.
(ACTIVITY) Student [Todd] nods head.		
PR:	Okay. Why do you think four?	The teacher responds to Todd's answer but does not evaluate it. She asks for further elaboration through

		the use of an open-ended question.
Todd:	(pause)	
Kristina:	(points to counters on floor) 'Cause there's four.	Kristina supports Todd's response as she builds on his answer.

Later on in the lesson, Alvin indicates he has an idea.

Alvin:	Ohhhh, I think I know!	Alvin shares his enthusiasm for problem-solving.
PR:	Alvin, what could I do?	Again, the teacher reinforces the idea that students are capable of solving problems when she asks for Alvin's input.
Alvin:	I forgot.	
PR:	You forgot? Okay Alvin's gonna think some more. What if, okay, it looks like we're kinda stumped. So I'm gonna put a tool out here. I wonder if we could use this tool to help us solve this problem?	The teacher supports Alvin by providing him with think time. She is responsive to the needs of the students, noting that students seem puzzled by the problem. She provides a manipulative to aid them in their thinking.
Madison:	Um, you can put um in front you can count um how many's in there how many's in there you gotta put um you gotta put some in there and count how many's down.	Madison shares an example of exploratory talk that is full of speech disfluencies.
PR	Okay, so I think what Madison's saying is we need to put some out? (points to cubes in center of carpet).	The teacher responds and attempts to revoice Madison's idea, checking for confirmation.

(ACTIVITY) Madison nods head.

PR:	Now who could add to Madison's idea? How many do we need to put out?	The teacher asks for help adding to Madison's idea. This suggests that students work together on ideas collaboratively.

Megan:	Um, we can um add more cubes to um the to those cubes (points to four cubes in middle of carpet) and um then you can add um more cubes and you make um that those cubes um to 10.	Megan builds on the previous ideas as she shares an example of exploratory talk.
PR:	Okay. So Megan has one idea. She says that we can add cubes points to four cubes laid in a row on carpet) to make 10 and see how many cubes we would have?	The teacher replies and revoices Megan's idea. She suggests that there can be more than one idea, emphasizing collaboration.

After the class assisted Megan in counting out 10 cubes, the conversation continued:

PR:	Okay, so we've got 10 cubes. Huh, did we figure it out? Did we solve it? Who says no? What do we need to do with the 10 cubes?	The teacher asks the students to determine if they've solved the problem, rather than telling them.
Kara:	(pause)	
PR:	We know Mrs. Bequette had four left over. How could we figure out how many's in my sack?	The teacher again supports and leads students through their puzzlement by reviewing the problem.
Kara:	(points to each of the cubes) Um	Kara begins a response.
PR:	What were you doing? I saw you doing something?	The teacher utilizes an open-ended question to draw out Kara's thinking.
Kara:	I counted the four and um there's six right there.	Kara shares an example of exploratory talk, revealing her mathematical thinking.

After Kara suggests there are six objects in the sack, the class is involved in shared decision-making.

PR:	Okay. Now what do you guys think? Do you agree with Kara or do you disagree?	Rather than evaluating Kara's response, the class is given an opportunity to agree or disagree.

SUMMARY

The primary purpose of this research study was to identify what was revealed in Kindergarten students' exploratory math talk. I sought to understand what mathematical knowledge was present in their talk. This required that I also examine the social context affecting the research. After analysis of the findings, seven conclusions were suggested. However, synthesis is necessary to gain a more complete understanding of what transpired.

A central research finding and conclusion was that the majority of exploratory talk was related to mathematics, specifically to number and operations. Other mathematical concepts were found to a lesser degree. As students shared their mathematical thinking through their words and actions, I, along with the reader, was given a glimpse into their mathematical minds that standard assessments might not reveal. However, this conclusion was situated within a more dynamic phenomena.

What was uncovered suggested that students were exchanging ideas with others, struggling to form their thoughts while speaking. These articulations were difficult to understand at times and were often accompanied by gestures and the use of fingers. One might conclude that these students were decentering as they attempted to make their perspective understood by others. As their ideas were exchanged and challenged, the students' own thinking was modified, reflecting a deeper understanding of the concept.

Supporting these exchanges was an evolving collaborative environment as evidenced by the social norms. This may lead one to conclude that the students and the teacher were on a journey of change—of putting into place constructivist theory into the real world of the classroom. Old behaviorist norms had to be overturned and were still found in some of the discourse. As the teacher and the students struggled with transformation, an emergence began—one that revealed the interplay between students' individual mathematical development intertwined with the social activity of mathematics. Supporting this emergence was the framework of exploratory talk which enabled the teacher to provide opportunities for students to exchange ideas, challenge, and modify their existing thinking. Exploratory talk promoted the construction of a collaborative discourse community ripe with mathematical learning.

RECOMMENDATIONS

Recommendations are offered based on the findings and conclusions of this study. The recommendations that follow are for: (a) early childhood educators, (b) teacher educators, (c) curriculum developers, (d) school districts, and (e) for further research.

Recommendations for Early Childhood Educators

For years, early childhood educators have been the recipients of research, much of which has been conducted by those outside of the classroom. This has resulted in a strong theory base on appropriate practices for young children. However, the current educational arena portrays a dichotomy between what young children *can* and *should* learn (Bredekamp, 2004). Inappropriate curriculum and teaching strategies are being forced down into the younger grades disguised as rigor and accountability. Recognizing that young children are capable learners able to construct their own understandings, those with a passion for early childhood education must carry the torch, engaging others in dialogue about what is an appropriate learning environment for the youngest learner. One such way is through the dissemination of teacher research.

When teachers engage in inquiry into their own teaching practices in a systematic way, growth is twofold. One, teacher empowerment becomes something not given by others, but rather an actualization of the power we hold as educators and what we do with this power for our youngest charges. When we simply implement without thought, without theory, without question, we not only discredit years of research but we set aside our own intuitive beliefs about how young children learn. Two, educators can add to the theory base on teaching and learning. I encourage and challenge teachers to step outside of their comfort zone, to ponder and ask, why am I teaching this? Does this correlate with what I know to be honest and true about my students? How can I, as a professional, change what I do for the betterment of those I teach? Through teacher research, real reform can begin where it is needed most—in the classroom. As we work to understand our students' understandings, we ultimately learn about ourselves. Through dissemination of these understandings, much needed conversations about learning can result.

Additionally, early childhood educators should recognize the centrality of number for mathematics instruction. Students need a strong foundation in number and operations. These understandings will support the development of other mathematical concepts, including geometry, measurement, data analysis, and algebra. While number is not directly teachable, the classroom environment can be set up to foster a child's logico-mathematical development. One such way is through the exchange of mathematical ideas with peers. Research indicates that this can be difficult to do with young children.

However, exploratory talk provides a framework for putting reform into action. As students share explanations, work through problems together, build upon and challenge ideas, they are hearing the reasoning of others. This can lead students to rethink and modify their own ideas that reflect a better understanding than they had. Additionally, when children are provided with opportunities to share, disagree, and negotiate, they learn to search within as they invent ways to solve mathematical problems rather than rely on external sources such as the teacher.

A collaborative classroom environment is not a quiet place. Rather, students are given opportunities to exchange ideas throughout the day which can result in a loud, boisterous room filled with energy, excitement, and a passion for learning exhibited by both the students and the teacher. Through this project, I have learned to listen to my students, drawing out their thinking through the use of open-ended questions and revoicing and responding rather than evaluating their answers. I had to learn to listen through my students' speech disfluencies for the emerging ideas and become attentive to their use of gesture as they shared their thinking.

Creating a constructivist mathematical classroom takes time. Students and the teacher alike have past experiences with schooling. These perceptions are brought into the classroom and significantly affect the learning that occurs. Become aware of the social norms in your classroom. Think about the words you use, how you respond when a child shares a wrong answer or maybe hears a different question than what you voiced. Be cognizant of the learning theory that underlies what you say and do. Changing classroom norms does not happen overnight. It requires honesty on the part of the educator in confronting the inconsistencies that exist between what we know is best for children and our actual practices. However, it is worth the effort as students and the teacher learn to think out loud and reason together mathematically.

Recommendations for Teacher Educators

I propose that teacher research is a primary means of reform and can do much to lessen the gap between theory and practice in education. It can be viewed not as something done in addition to teaching, but rather as a powerful component of teaching and learning. Opportunities to question one's own practice and engage in systematic inquiry can be provided throughout a teacher's educational career beginning at the preservice stage. Teacher educators can play a pivotal role in the process as they engage in their own teacher research studies and support research conducted by both novice and experienced teachers. One such way is through the establishment of teacher inquiry communities (Cochran-Smith & Lytle, 1993).

Teacher inquiry communities are forums within schools, districts, and communities that provide opportunities for educators to inquire into their own practices with the help of knowledgeable others. Teacher research can be a daunting task as teachers are already overwhelmed with the multitude of roles they play on a daily basis. However, I believe that many teachers recognize that standardized test scores currently drive teaching and learning, limiting our role as little more than the giver of others' knowledge. Through teacher inquiry communities, teachers can become agents of change for their schools, blurring the lines between teachers and researchers. Educators at all levels can learn to work together to reinterpret how learning and teaching are viewed and implemented in the classroom. "When teachers redefine their own relationships to knowledge about teaching and learning, they reconstruct their classrooms and begin to offer different invitations to their students to learn and know" (Cochran-Smith & Lytle, 1993, p. 101).

Recommendations for Curriculum Developers

As I began this project, I spent time researching possible problem-solving curricula. While I was expected to use the district-adopted curriculum, I wanted to utilize additional resources as well. What I typically found were problems that did little to evoke the puzzlement and relevance needed to truly challenge my students. Many so-called problem-solving activities were simply story problems. With this in mind, I would like to recommend the following for curriculum developers in creating problem-solving activities for young children. There is a need for problems that are both challenging yet solvable for young children. As evidenced by this research study, children were able to solve rather complex problems collaboratively with the teacher acting as a discourse guide. It would be beneficial to have resources available that can support their mathematical thinking. Such curricula might include ideas on making problems context-specific. The problems that were related to the classroom were much more meaningful for the students. However, teachers need guidance in creating these. Additionally, suggestions might be given on how to extend the problems. For this research study, a problem was shared in a whole group setting. Students then met with small groups to solve similar problems, building on their experiences gained during the whole group activity. Finally, ideas on how to transform a classroom into a problem-solving environment in which students apply problem-solving strategies not only to mathematics but to other parts of the school day would be helpful.

Recommendations for School Districts

The early childhood classroom has changed in recent years. In many environments, blocks have been replaced by a research-based curriculum; opportunities to engage in painting, dramatic play, and sand exploration are set aside, utilized only when more academic pursuits allow time. Additionally, the classroom day has become tightly segmented into large blocks of time designated for literacy and mathematics, allowing little opportunity for integration. To the layman, these indicators might suggest that learning activities have been "beefed up." A closer look, however, reveals a classroom robbed of joy, spontaneity, and whimsy as learning once again is defined as a series of steps to be implemented before the child progresses to the next level. I must question have children really changed or have our perceptions of what they *can* and *should* become distorted?

I would like to suggest to school districts that learning for young children can be rigorous yet appropriate. When learning is reduced to telling, we limit children's tremendous ability to invent and construct knowledge on their own. Through this research project, I hoped to demonstrate that young children are capable of engaging in complex mathematics as they problem-solve and exchange ideas with their peers. Children have much to share through their words and actions which need to define how learning is viewed in our classrooms.

<u>Recommendations for Further Research</u>

Further studies should be conducted to develop a larger theory base of exploratory math talk to assess the extent to which similar findings are revealed. A similar study undertaken with different age groups would also be beneficial. In addition, an examination of the social norms in a traditional mathematics classroom as well as a more constructivist-minded classroom is needed. Finally, it is important to add to the theory base on implementing mathematics reform into early childhood classrooms.

FINAL THOUGHTS

"The real learning can only take place in the doing" (Merriam, 1998, p. 156).

Beginnings

As this research study draws to a close, I find myself with a feeling of ambivalence: at times, triumphant that I survived the dreaded dissertation process; other times, with a sense of loss as I contemplate the future without my question. This research project began with a passion: for teaching, for mathematics, and for children. Through my classroom experiences, I discovered my question: what do children truly know about mathematics? I felt they knew more than what standard assessments revealed. My experiences as a parent taught me the power of language. I found that my words could be the spark that ignited my children's learning or could quickly dim their bright curiosity. Surely this happens in the classroom too, I reflected. As I began to research classroom talk, what I discovered fueled my question. I found myself joining the multitudes throughout the ages that have asked what is the link between language and learning.

> I now believe that Action Research is as much a process of asking questions about one's practice as it is deciding what to do about solutions. Action Research enables you to live your questions; in a way, they become the focal point of your thinking (Battaglia, 1995, p. 89).

Somewhere In the Middle

During this journey, I left behind my old self-- someone unsure of what being a teacher researcher entailed. Slowly, almost unknowingly, I stepped onto a new shore—one that embraced uncertainty as part of the journey; puzzlement as part of the learning; honesty as part of the change—all of which encompass what it means to be a teacher who is a researcher.

Throughout this project, I have had to venture out of my comfort zone in a multitude of ways. From learning new technology to confronting myself on tape--this dual role as a teacher/researcher asked that I objectively evaluate both my successes and failures as a teacher through a constructivist lens. As a teacher, I saw much to feel good about, yet I had to be honest about my own inconsistencies between my philosophy and actual teaching practices. As a researcher, I was able to view my failures not as barriers but as stepping stones to becoming what I envision a constructivist educator to be.

<u>Endings And New Beginnings</u>

As I enter the classroom each day, I find myself armed not only with a curriculum, but with the learning that I have fueled as a teacher researcher. Lessons learned include the power of children's voices that have much to say about what they need to develop mathematically. This project that began with a question about my students' mathematical abilities has become much more as I grow to understand that the power is not in perfection but in acceptance of the journey, the struggles, and the inconsistencies. It is the combination of these experiences that can slowly transform both the teaching and the classroom environment and ultimately, myself. As a teacher researcher, I must accept the messiness of classroom life as working with young children is never static. However, out of chaos can arise grandeur as I glimpse the power of constructivism embedded in the process of becoming a constructivist educator.

> There is no point of arrival, but rather a path that leads on to further growth and change. For those who are willing to face the doubts, frustrations, and uncertainties inherent in a practice based on constructivism, that path is also filled with rewards and satisfactions (Schifter, 2005, p. 96).

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APPENDIX A

IRB Approval Letter

Oklahoma State University Institutional Review Board

Date:	Thursday, January 17, 2008
IRB Application No	ED07122
Proposal Title:	Kindergarten Students' Exploratory Math Talk
Reviewed and Processed as:	Expedited (Spec Pop)

Status Recommended by Reviewer(s): Approved Protocol Expires: 1/16/2009

Principal Investigator(s

Sandra Bequette 3138 N. Lakecrest Wichita, KS 67205	Kathryn Castle 235 Willard Stillwater, OK 74078

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

☑ The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval.
2. Submit a request for continuation if the study extends beyond the approval period of one calendar year. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of this research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Beth McTernan in 219 Cordell North (phone: 405-744-5700, beth.mcternan@okstate.edu).

Sincerely,

Shelia Kennison, Chair
Institutional Review Board

APPENDIX B

Initial Parent Contact Script

Hello! I wanted to tell you about a special research project I will be doing in our Kindergarten class beginning in February, 2008. It is on classroom math talk. I am wanting to understand how children share their math knowledge through their talk. Our mathematics program will stay the same. However, I am wanting to collect data that will help me understand math talk better. This will include video taping students during whole group math lessons and audio taping them during small group time. This will be done twice a week. In addition, I will record observations about students' math talk in other areas of the curriculum, such as during center time. I will share information about the study results in a written report (dissertation) for Oklahoma State University.

The research project is voluntary. You, as your child's parent (or guardian) can choose to not have your child participate. If so, your child will not be included in the study, but will still participate in regular classroom activities. [Display consent form]. This is a consent form that should explain in more detail what I will be doing. Please look it over and let me know of any questions or concerns you might have. Please complete the form, either giving or not giving your consent for your child to participate in the research study and return it to me by Monday, Feb 4.

APPENDIX C

Parent Permission Form

Okla. State Univ.
IRB
Approved 1/17/08
Expires 1/16/09
IRB# ED07122

Parent Permission Form

Project Title: Kindergarten Students' Exploratory Math Talk

Investigators: Sandra L. Bequette, M.Ed..

Purpose: The purpose of the research study is to better understand how children share their math knowledge through their talk.

It focuses on understanding the different types of talk used in my classroom during math lessons and will involve video tapes of whole group math lessons and audio tapes of small group activities. I, as the teacher, and the students will be recorded as we talk and interact during math time. In addition, student work may be collected that helps to understand student thinking as well as photographs of small group work. Classroom observations of students' math talk in other curriculum areas will also be recorded in a research journal.

Procedures: The mathematics program will not be any different from what we are currently doing in the classroom. All students, whether they have consent to participate in the research study or not, will participate in regular classroom activities. Procedures include:

- During whole group math instruction, the teacher will share a meaningful math problem with the class from the district math curriculum. Students will discuss the problem and identify possible strategies to solve it. Students will be video-taped as they engage in discussion. Students without parental consent will sit outside the range of the camera.
- Next, students will select from a variety of math activities around the classroom. One table in the classroom will be designated the problem-solving table. Student groups will rotate turns working at the table as they solve a problem similar to the whole group activity. Students without parental consent will not be grouped with study participants during small group work.
- Student conversations will be audio-recorded while working at the problem-solving table. In addition, student photographs may be taken to add important details about student conversations. Samples of student work may also be collected (i.e., drawings, journals, writing).
- Observations of students, including a written record of their math talk will be gathered and recorded in a research journal to show if students use math talk during other parts of the day (i.e., centers). Observations of non-participants will not be conducted.

Risks of Participation:

There are no known risks associated with this project which are greater than those ordinarily encountered in daily life.

Benefits:

Benefits from the research include possible information about students' progress in mathematics. In addition, it may contribute to research in general on math talk in Kindergarten students.

Confidentiality:

To ensure confidentiality and protection for your child, I assure you that:

- Tapes will only be used for research purposes.
- You may ask to view or listen to any tapes that record your child.
- You may request that parts of tapes of your child not be shown to others.

All data will be analyzed and stored off-site. Data will be stored utilizing an off-site password-protected computer. Audio- and video-tapes will be stored in a locked file cabinet in the home of the primary researcher with only the primary researcher having access. Tapes will be kept for a maximum of two years and then destroyed.

Data will be reported in the primary researcher's dissertation for Oklahoma State University. In addition, data may be shared in scholarly journals. Student identities will be protected utilizing student pseudonyms.

The records of this study will be kept private. Any written results will discuss group findings and will not include information that will identify your child. Research records will be stored securely and only researchers and individuals responsible for research oversight will have access to the records. It is possible that the consent process and data collection will be observed by research oversight staff responsible for safeguarding the rights and wellbeing of people who participate in research.

Compensation:

There is no compensation for participating in the study other than the possible benefit of better understanding your child's math knowledge.

If you do not wish your child to participate in the study, he or she will not be included in the study but will participate in regular classroom activities. This may include sitting outside the range of the video camera and not having small group math conversations recorded.

Okla. State Univ.
IRB
Approved 1/17/08
Expires 1/16/09
IRB# ED07122

Contacts:

If you have questions concerning the research or your child's rights as a research participant, please contact:

Sandra Bequette
3138 N. Lakecrest
Wichita, KS 67205
316 558-8674

or

Dr. Kathryn Castle
STCL Graduate Coordinator
235 Willard Hall
Oklahoma State University
Stillwater, OK 74078
405 744-8019

If you have questions about your rights as a research volunteer, you may contact Shelia Kennison, IRB Chair, 219 Cordell North, Stillwater, OK 74078, 405-744-1676 or irb@okstate.edu.

Participant Rights:

Involvement in the research project is voluntary and you can withdraw your child at any time in the research project without reprisal or penalty. If you decide to withdraw your child from the project, then recordings of your child will not be used.

APPENDIX D

Student Assent Script

Okla. State Univ.
IRB
Approved 1/17/08
Expires 1/16/09
IRB# ED07122

Verbal Script for Students' Assent

Hello, ________ (student name). Today, I am going to record our math talk using a video camera and a tape recorder. You don't need to be part of the taping if you don't want, and you can change your mind about being taped any time and for any reason. If you don't wish to participate, your grade won't be affected and you won't be in trouble. Would you like to be part of the audio and video tape?

APPENDIX E

IRB Continuation Approval Letter

Oklahoma State University Institutional Review Board

Date	Wednesday, December 17, 200	**Protocol Expires:**	12/16/2009
IRB Application No:	ED07122		
Proposal Title:	Kindergarten Students' Exploratory Math Talk		

Reviewed and Processed as: Expedited (Spec Pop)
Continuation

Status Recommended by Reviewer(s) **Approved**

Principal Investigator(s)

Sandra Bequette 3138 N. Lakecrest Wichita, KS 67205	Kathryn Castle 235 Willard Stillwater, OK 74078

Approvals are valid for one calendar year, after which time a request for continuation must be submitted. Any modifications to the research project approved by the IRB must be submitted for approval with the advisor's signature. The IRB office MUST be notified in writing when a project is complete. Approved projects are subject to monitoring by the IRB. Expedited and exempt projects may be reviewed by the full Institutional Review Board.

☐ The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

The reviewer(s) had these comments:

Approval for continued data analysis only. Should additional data collection be necessary a modification will need to be submitted to the IRB for review and approval prior to implementation.

Signature:

Shelia Kennison, Chair, Institutional Review Board

Wednesday, December 17, 200
Date

APPENDIX F

Coding Legend

1. Mathematical understanding

   Number
   - MNumber1 Verbal counting
   - MNumber2 Object counting
   - MNumber3 Subitizing
   - MNumber4 Comparing numbers
   - MNumber5 Adding to/taking away
   - MNumber6 Compose and decompose

   Algebra
   - MAlgebra1 Repeating patterns
   - MAlgebra2 Growing patterns

   Geometry
   - MGeo1 Shapes
   - MGeo2 Putting together shapes
   - MGeo3 Transformation and symmetry
   - MGeo4 Spatial reasoning/locations

   Measurement
   - MMsmt1 Attributes, units, processes
   - MMsmt2 Techniques and tools

   Data Analysis
   - MData1 Classification
   - MData2 Graphing

   Errors: regular coding followed by “E”
   Talk about: regular coding followed by “T”

2. Sounds like?

   Irregular speech:
   - IS1 Pauses
   - IS2 “Um”
   - IS3 Repetition
   - IS4 Abbreviation
   - IS5 “Like”
   - IS6 Other

   Other:
   - SL1 Shares thinking
   - SL2 Revises thinking
   - SL3 Statements offered for joint consideration
   - SL4 Request for clarity
   - SL5 Ideas may be challenged but justified
   - SL6 Theory building
   - SL7 Joint agreement
   - SL8 Using evidence
   - SL9 Sets up hypotheses
   - SL10 Reaches conclusions
   - SL11 Other

3. When does it occur?
    - When1 Whole group discussions
    - When2 Small group discussions
    - When3 Other times of the day
4. Teacher Support
    - TSupp1 Open-ended probing questions
    - TSupp2 Reply not assess
    - TSupp3 Tools
    - TSupp4 Teacher as peer
    - TSupp5 Review
    - Tsupp6 Lead through puzzlement
    - TSupp7 Informal use of math language
    - TSupp8 Revoice
    - TSupp9 Other
5. Social norms
    - Soc1 Shared decision-making
    - Soc2 Conflict
    - Soc3 Ideas
    - Soc4 Problems
    - Soc5 Old norms
    - Soc6 Other
6. Accompanies exploratory talk
    - Acc1 Gestures
    - Acc2 Uses fingers
    - Acc3 Other
7. Miscellaneous
    - M Miscellaneous utterances

APPENDIX G

Example of Coded Discourse

# of utterance	Discourse	Coding Example
G2W11.006	PR: And we have kind of a fun problem to solve today. Count how many shapes:	Soc4 (problems are exciting) Soc4 (problem-solve) M
G2W11.007	Students: 1 2 3 4 5	M
G2W11.008	PR: We need to figure out which of these shapes holds the most. How could we figure that out? What do you think, Javier?	Soc4 (figure out/investigate) TSupp1 (how) Soc1 (what do you think?)
G2W11.009	Javier: Um I think it should be the biggest one	IS2 (um) When2 (SG) SL9 (hypotheses)
G2W11.010	PR: Okay. How can you tell which is the biggest since they're all different shapes?	TSupp2 (okay) TSupp1 (how)
G2W11.011	Javier: This one	M
G2W11.012	PR: So--do you remember what we call that shape?	M
G2W11.013	Javier: Um--a square	M
G2W11.014	PR: A square. Who remembers our three-dimensional name for it? Do you remember? I put it in drinks to make it cold.	TSupp8 (revoice) M (remaining utterances are closed questions)
G2W11.015	Kristina: Um ice	M
G2W11.016	Javier: ice	M
G2W11.017	PR: Ice--	M
G2W11.018	Javier: Cube!	M
G2W11.019	PR: Cube--we do call that a cube.	TSupp8 (revoice) TSupp7 (cube)
	So Javier predicts the cube is the biggest. Do you guys agree or disagree?	TSupp8 (revoice) Soc1 (agree/disagree)
	Is the cube gonna hold the most?	TSupp8 (revoice)
	Kristina, show us your answer.	Soc3 (show idea)
	Kristina says she disagrees. Why do you disagree?	M (not actual revoice); TSupp1 (why)
G2W11.020	Kristina: 'Cause this one it's like longer and taller	When2 (SG) IS4 (abbreviation) IS5 (like) SL5 (challenge)

APPENDIX H

Data Summary Tables: Finding 1

Mathematical Understandings

Black=whole group
Red=small group
Blue=other

Data Summary Table: Finding 1 Number & Operations

e=error

	Verbal Counting			Object counting			Subitizing			Compare #s			Add/take away			Compose & Decompose			TOTAL WG	TOTAL SG	TOTAL Other	Do	Talk	Errors
Chris	2	4	0	4,2T	10,4T	0	0	0	0	0	7	0	1,1T	4	0	0	0	0	7,3T	25,4T	0	32	7	0
Alex	0	6	0	1e	6	0	0	0	0	0	0	0	0	0	0	0	0	0	1e	12	0	12	0	1
Stacey	0	1	0	1e	3,2T	1	0	0	0	0	0	0	1e	0	1	0	0	0	2e	4,2T	2	6	2	2
Jacob	0	0	0	2,1e	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,1e	0	0	2	0	1
Madison	2	2	0	5,5T	2,4T	1	0	0	0	1	1	0	1,2e	2	0	0	0	0	9,5T,2e	7,4T	1	17	9	2
Tiara	0	7	0	1,1T	6,3T	0	0	0	0	0	0	0	4	2	0	0	0	0	5,1T	15,3T	0	20	4	0
Mia	2	3	0	5,1T	3,1T	0	0	0	0	0	0	0	3,1e	1e	0	0	0	0	10,1T,1e	6,1T,1e	0	16	2	2
Alvin	0	1	0	3,1e	3,1T	0	0	0	0	1	0	0	1e	1e	0	0	0	0	4,2e	4,1T,1e	0	8	1	3
Jamie	0	0	0	0	1T	0	0	0	0	0	0	0	2	0	0	1	0	0	3	1T	0	3	1	0
Kara	3	4	0	4,1T	4,2T	0	1	0	0	0	2	0	9,1e	1	0	0	0	0	17,1T,1e	11,2T	0	28	3	1
Ivan	0	3	0	1e	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1e	7	0	7	0	1
Steven	1	10	0	3,1T	12,1T	0	0	0	0	0	0	0	2,2e	0	0	0	0	0	6,1T,2e	22,1T	0	28	2	2
Colby	0	5	0	1,1T	7,2T	0	0	0	0	0	0	0	1T	0	0	0	0	0	1,2T	12,2T	0	13	4	0
Javier	0	5	0	2,1T	5,2T,1e	0	0	0	0	0	0	0	1,1e	1	0	0	0	0	3,1T,1e	11,2T,1e	0	14	3	2
Megan	1	1	0	0	3,4T	0	0	0	0	1	0	0	4,1e	1	0	0	0	0	6,1e	5,4T	0	11	4	1
Michael	0	0	0	1T	1T	0	0	0	0	1	0	0	1e	0	0	0	0	0	1,1T,1e	1T	0	1	2	1
Todd	0	1	0	0	2	0	0	0	0	0	1	0	0	1e	0	0	0	0	0	4,1e	0	4	0	1
Adriana	0	12	0	0	11,1T	0	0	0	0	0	0	0	1	2,1e	0	0	0	0	1	25,1T,1e	0	26	1	1
Aaron	6	18	0	14,6T,2e	22,4T,3e	0	0	0	0	1	1	0	3,1T,3e	7	0	0	0	0	24,7T,5e	48,4T,3e	0	72	11	8
Kristina	1	3	0	2,2T,1e	5,5T	1	0	0	0	0	1	0	0	2	0	1	0	0	4,2T,1e	11,5T	1	16	7	1
Justin	1	7,1e	0	1,1T	1,1T,2e	0	0	0	0	0	0	0	1e	0	0	0	0	0	2,1T,1e	8,1T,3e	0	10	2	4
TOTAL	19	93,1e	0	47,23T, 8e	109, 39T,6e	3	1	0	0	5	13	0	31,3T, 15e	22, 4e	1	2	0	0	105, 26T, 23e	237,39T,11e	4	346	65	34

Black=whole group
Red=small group
Blue=other

Data Summary Table: Finding 1 Measurement

#=do
T-talk
e=error

	Attributes, units, and processes			Techniques & Tools			TOTAL					
							WG	SG	Other	Do	Talk	Errors
Chris	3	12	0	1T,1e	2,2T	0	3,1T,1e	14,2T	0	17	3	1
Alex	1	2,2e	0	1T	1,3T	0	1,1T	3,3T,2e	0	4	4	2
Stacey	0	2	0	0	1e	0	0	2,1e	0	2	0	1
Jacob	0	0	0	0	0	0	0	0	0	0	0	0
Madison	2e	0	0	0	1T	0	2e	1T	0	0	1	2
Tiara	2	5	0	0	1,2T	0	2	6,2T	0	8	2	0
Mia	0	1	0	0	2,1T,1e	0	0	3,1T,1e	0	3	1	1
Alvin	1T	1e	0	0	0	0	1T	1e	0	0	1	1
Jamie	0	0	0	0	1T	0	0	1T	0	0	1	0
Kara	1,1e	1	0	1e	1T	0	1,2e	1,1T	0	2	1	2
Ivan	0	0	0	0	0	0	0	0	0	0	0	0
Steven	3	2e	0	2,3T	0	0	5,3T	2e	0	5	3	2
Colby	0	0	0	0	0	0	0	0	0	0	0	0
Javier	5	5,1e	0	0	1,1T	0	5	6,1T,1e	0	11	1	1
Megan	0	3	0	0	3T	0	0	3,3T	0	3	3	0
Michael	0	0	0	0	0	0	0	0	0	0	0	0
Todd	0	2	0	0	1T	0	0	2,1T	0	2	1	0
Adriana	2	8	0	1T	3,1T	0	2,1T	11,1T	0	13	2	0
Aaron	2	3	0	1	4,3T	0	3	7,3T	0	10	3	0
Kristina	2	6,1T,7e	0	0	1T	0	2	6,2T,7e	0	8	2	7
Justin	0	2	0	0	0	0	0	2	0	2	0	0
TOTAL	21,1T,3e	52,1T,13e	0	3,6T,2e	14,21T,2e	0	24,7T,5e	66,22T, 15e	0	90	29	20

Black=whole group
Red=small group
Blue=other

Data Summary Table: Finding 1 Data Analysis

#=do
T-talk
e=error

	Classification			Representation (Graphing, Chart)			TOTAL WG	SG	Other	DO	Talk	Errors
Chris	1	8	0	7T	1T	0	1,7T	8,1T	0	9	8	0
Alex	0	1e	0	0	1T	0	0	1T, 1e	0	0	1	1
Stacey	0	1	0	1	1T	0	1	1,1T	0	2	1	0
Jacob	0	0	0	0	0	0	0	0	0	0	0	0
Madison	0	1e	0	3T	0	0	3T	1e	0	0	3	1
Tiara	1	2	0	0	2	0	1	4	0	5	0	0
Mia	0	3	0	0	2,2T	0	0	5,2T	0	5	2	0
Alvin	0	1e	0	1	2,2T	0	1	2,2T,1e	0	3	2	1
Jamie	0	0	0	1	1	0	1	1	0	2	0	0
Kara	2	2	0	1,7T	1	0	3,7T	3	0	6	7	0
Ivan	0	0	0	0	0	0	0	0	0	0	0	0
Steven	1	1	0	0	1	0	1	2	0	3	0	0
Colby	0	0	0	2T	0	0	2T	0	0	0	2	0
Javier	1	2	0	1	0	0	2	2	0	4	0	0
Megan	0	3	0	1	4T	0	1	3,4T	0	4	4	0
Michael	0	0	0	2T	1T	0	2T	1T	0	0	3	0
Todd	0	2	0	0	0	0	0	2	0	2	0	0
Adriana	3	4	0	1T	1,2T	0	3,1T	5,2T	0	8	3	0
Aaron	0	2	0	1,1T	2	0	1,1T	4	0	5	1	0
Kristina	1	3	0	1T	0	0	1,1T	3	0	4	1	0
Justin	0	2,2e	0	0	0	0	0	2,2e	0	2	0	2
TOTAL	10	35,5e	0	7,24T	12,14T	0	17,24T	47,14T,5e	0	64	38	5

Black=whole group
Red=small group
Blue=other

Data Summary Table: Finding 1 Geometry

#=do
T-talk
e=error

	Shapes			Putting together shapes			Transformation & Symmetry			Spatial Awareness /Location			TOTAL					
													WG	SG	Other	Do	Talk	Errors
Chris	1	3	0	0	0	0	0	0	0	0	1	0	1	4	0	5	0	0
Alex	0	1	0	0	0	0	0	0	0	0	1	0	0	2	0	2	0	0
Stacey	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0
Jacob	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Madison	0	0	0	0	0	0	0	0	0	0	2	0	0	2	0	2	0	0
Tiara	0	0	0	0	0	0	0	0	0	0	2	0	0	2	0	2	0	0
Mia	0	3	0	0	1T	0	0	0	0	0	0	0	0	3,1T	0	3	1	0
Alvin	0	0	0	0	0	0	0	0	0	0	1e	0	0	1e	0	0	0	1
Jamie	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kara	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0
Ivan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Steven	0	1	0	0	0	0	0	0	0	0	2e	0	0	1,2e	0	1	0	2
Colby	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Javier	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0
Megan	0	2	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	0
Michael	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Todd	0	1	0	0	0	0	0	0	0	0	1	0	0	2	0	2	0	0
Adriana	0	4	0	0	0	0	0	0	0	0	2	0	0	6	0	6	0	0
Aaron	0	8	0	0	0	0	0	0	0	0	1e	0	0	8,1e	0	8	0	1
Kristina	0	0	0	0	0	0	0	0	0	0	2	0	0	2	0	2	0	0
Justin	0	1e	0	0	0	0	0	0	0	0	0	0	0	1e	0	0	0	1
TOTAL	1	23,1e	0	0	1T	0	0	0	0	0	14,4e	0	1	37, 1T,5e	0	38	1	5

Black=whole group
Red=small group
Blue=other

Data Summary Table: Finding 1 Algebra

#=do
T-talk
e=error

	Repeating Pattern (ABAB)			Growing Pattern (ABABBABBB)			TOTAL					
							WG	SG	Other	Do	Talk	Errors
Chris	2	1	0	0	0	0	2	1	0	3	0	0
Alex	0	0	0	0	0	0	0	0	0	0	0	0
Stacey	0	0	0	0	0	0	0	0	0	0	0	0
Jacob	0	0	0	0	0	0	0	0	0	0	0	0
Madison	0	0	0	0	0	0	0	0	0	0	0	0
Tiara	0	0	0	0	0	0	0	0	0	0	0	0
Mia	0	0	0	0	0	0	0	0	0	0	0	0
Alvin	1	0	0	0	0	0	1	0	0	1	0	0
Jamie	0	0	0	0	0	0	0	0	0	0	0	0
Kara	0	0	0	0	0	0	0	0	0	0	0	0
Ivan	0	0	0	0	0	0	0	0	0	0	0	0
Steven	0	1T	0	0	0	0	0	1T	0	0	1	0
Colby	0	0	0	0	0	0	0	0	0	0	0	0
Javier	0	0	0	0	0	0	0	0	0	0	0	0
Megan	1	1	0	0	0	0	1	1	0	2	0	0
Michael	0	0	0	0	0	0	0	0	0	0	0	0
Todd	0	0	0	0	0	0	0	0	0	0	0	0
Adriana	0	0	0	0	0	0	0	0	0	0	0	0
Aaron	0	2	0	0	0	0	0	2	0	2	0	0
Kristina	0	0	0	0	0	0	0	0	0	0	0	0
Justin	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	4	4,1T	0	0	0	0	4	4,1T	0	8	1	0

APPENDIX I

Data Summary Table: Finding 2

What Does Exploratory Talk Sounds Like?

Speech Disfluencies

Black=whole group
Red=small group
Blue=other

Data Summary Table: Finding 2 Irregular Speech

	False start			Pause			Um			Repetition			Like			Uh			Abbreviated			Overlapping		
Chris	0	1	0	5	6	0	30	26	0	3	9	0	5	7	0	1	0	0	10	5	0	0	1	0
Alex	0	0	0	2	3	0	1	5	0	2	7	0	1	5	0	0	0	0	2	7	0	0	0	0
Stacey	0	2	0	3	3	0	0	3	0	0	0	0	0	0	0	1	0	0	3	3	0	0	0	0
Jacob	0	0	0	2	0	0	1	1	0	3	2	0	0	0	0	2	3	0	0	0	0	0	0	0
Madison	0	0	0	3	2	0	18	14	0	8	4	0	1	2	0	5	2	0	1	1	0	1	0	0
Tiara	0	0	0	1	1	0	14	3	0	0	0	0	1	4	0	0	4	0	1	10	0	0	4	0
Mia	0	0	0	2	1	0	2	4	0	0	3	0	0	0	0	0	0	0	0	1	0	0	0	0
Alvin	0	0	0	4	0	0	7	6	0	5	3	0	1	0	0	0	2	0	2	1	0	0	0	0
Jamie	1	0	0	0	1	0	3	1	0	1	0	0	0	0	0	2	1	0	0	0	0	0	0	0
Kara	0	1	0	8	0	0	34	8	0	11	0	0	10	5	0	1	3	0	1	3	0	0	0	0
Ivan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Steven	0	2	0	0	0	0	6	6	0	6	5	0	3	3	0	0	0	0	4	4	0	0	0	0
Colby	0	0	0	1	0	0	3	5	0	1	0	0	1	2	0	0	0	0	2	1	0	0	0	0
Javier	0	4	0	6	0	0	24	14	0	2	3	0	11	6	0	2	1	0	6	4	0	0	0	0
Megan	0	0	0	6	2	0	20	6	0	8	4	0	1	1	0	1	3	0	2	1	0	1	4	0
Michael	0	0	0	2	0	0	4	1	0	4	0	0	3	1	0	0	1	0	0	0	0	0	0	0
Todd	0	1	0	1	0	0	3	4	0	0	5	0	0	1	0	0	2	0	1	5	0	0	0	0
Adriana	0	0	0	2	2	0	2	8	0	0	0	0	0	0	0	0	0	0	3	6	0	0	0	0
Aaron	0	2	0	2	5	0	21	19	0	2	6	0	1	9	0	3	2	0	6	7	0	0	1	0
Kristina	0	2	0	4	1	0	7	9	0	4	1	0	1	0	0	1	1	0	3	10	0	0	0	0
Justin	0	0	0	1	0	0	7	8	0	4	2	0	2	0	0	1	0	0	1	1	0	0	0	0
TOTAL	1	15	0	55	27	0	207	151	0	64	54	0	42	46	0	20	25	0	48	70	0	2	10	0

APPENDIX J

Data Summary Table: Finding 3

What Does Exploratory Talk Sounds Like?

Black=whole group
Red=small group
Blue=other

Data Summary Table: Finding 2 Other/Exploratory talk

	Shares thinking			Revises thinking			Challenges			Sets up hypothesis			Clarity			Joint consideration			Theory building			Joint agreement			Uses evidence			Draws conclusion		
Madison	19	20	2	0	0	0	1	3	0	2	7	0	3	4	0	12	11	0	0	2	0	0	2	1	1	2	0	0	1	0
Tiara	17	34	0	0	0	0	0	4	0	3	12	0	1	0	0	3	8	0	0	0	0	0	1	0	1	3	0	0	1	0
Alvin	20	14	0	2	4	0	1	4	0	3	3	0	2	1	0	1	3	0	0	0	0	3	0	0	0	1	0	0	0	0
Kara	30	20	0	1	0	0	3	3	0	3	6	0	0	2	0	15	5	0	0	1	0	3	0	0	7	1	0	1	0	0
Ivan	3	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Megan	20	21	0	1	0	0	0	7	0	4	8	0	0	1	0	9	9	0	0	1	0	1	2	0	1	1	0	0	1	0
Jamie	8	5	0	0	0	0	0	0	0	2	1	0	0	0	0	1	4	0	0	1	0	1	0	0	1	0	0	0	0	0
Steven	23	32	0	0	2	0	3	4	0	4	12	0	1	2	0	3	3	0	1	0	0	1	3	0	7	1	0	0	1	0
Javier	29	25	1	0	4	0	1	7	0	5	12	0	0	3	0	4	11	0	0	1	0	1	4	0	6	0	0	0	3	0
Kristina	11	31	0	0	0	0	0	10	0	2	9	0	0	2	0	8	15	1	0	1	0	1	0	0	0	3	0	1	2	0
Justin	9	16	0	0	0	0	1	1	0	1	9	0	0	1	0	2	6	0	0	0	0	0	0	0	1	0	0	0	0	0
Mia	13	16	0	0	2	0	0	4	0	0	9	0	0	1	0	0	8	0	0	1	1	0	0	0	0	0	0	1	4	0
Adriana	11	33	0	0	0	0	1	2	0	1	9	0	0	0	0	2	7	0	0	1	0	1	2	0	0	2	0	1	3	0
Alex	8	33	0	0	1	0	4	6	0	0	11	0	0	1	0	1	7	0	0	1	0	0	1	0	1	2	0	0	2	0
Stacey	3	15	0	0	1	0	2	2	0	1	5	0	0	0	0	3	8	0	0	0	0	0	1	0	0	0	0	0	2	0
Jacob	9	3	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Colby	6	10	0	0	0	0	0	2	0	0	1	0	0	1	0	2	4	0	0	0	0	0	1	0	0	0	0	0	0	0
Michael	9	7	0	0	0	0	1	0	0	0	0	0	1	0	0	2	3	0	0	1	0	0	0	0	0	0	0	2	0	0
Todd	3	18	0	0	1	0	0	13	0	2	5	0	0	5	0	1	1	0	0	0	0	0	5	0	1	3	0	0	1	0
Chris	24	59	0	5	4	0	10	12	0	8	18	0	0	5	0	12	17	0	2	4	0	3	6	0	2	11	0	0	2	0
Aaron	39	78	0	0	1	0	0	10	0	7	23	0	0	10	0	10	18	0	0	3	0	0	7	0	3	15	0	0	0	0
TOTAL	314	495	3	9	20	0	28	94	0	48	160	0	8	39	0	92	149	1	3	18	1	15	35	1	32	45	0	6	23	0

APPENDIX K

Data Summary Table: Finding 4

What Accompanies Exploratory Talk?

Black=whole group
Red=small group
Blue=other

Data Summary Table: Finding 3 Accompanies Exploratory Talk

	Gestures			Uses fingers		
Chris	6	0	0	5	0	0
Alex	4	0	0	0	0	0
Stacy	0	0	0	0	0	0
Jacob	0	0	0	0	0	0
Madison	7	0	0	0	0	0
Tiara	3	0	0	1	0	0
Mia	1	0	0	0	0	0
Alvin	2	0	0	0	0	0
Jamie	0	0	0	0	0	0
Kara	13	0	0	7	0	0
Ivan	0	0	0	0	0	0
Steven	5	0	0	2	0	0
Colby	2	0	0	1	0	0
Javier	10	0	0	1	0	0
Megan	9	0	0	1	0	0
Michael	0	0	0	0	0	0
Todd	0	0	0	0	0	0
Adriana	1	0	0	1	0	0
Aaron	4	0	0	1	0	0
Kristina	3	0	0	0	0	0
Justin	4	0	0	0	0	0
SUMMARY	74	0	0	20	0	0

APPENDIX L

Data Summary Tables: Finding 5

When Does Exploratory Talk Occur?

Note: weeks 1-3; 6-7 had two lessons per week; others only one

Data Summary Table: Finding 3 WG Exploratory Talk

Student	Week 1		Week 2		Week 3		Week 4	Week 5	Week 6		Week 7		Week 8	Week 9	Week 10	Week 11	Week 12	TOTAL
	1.1	1.2	2.1	2.2	3.1	3.2			6.1	6.2	7.1	7.2						
Madison	0	6	1	6	0	4	4	2	3	0	2	0	0	6	1	1	1	36
Ivan	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Megan	0	2	1	7	2	0	8	2	3	1	0	1	1	0	2	2	1	33
Alvin	0	2	3	2	10	1	1	1	2	3	1	2	1	0	2	0	0	31
Tiara	0	1	1	5	2	2	1	1	0	0	2	1	2	1	1	3	1	24
Kara	5	0	0	7	1	5	3	3	4	0	7	4	4	3	2	5	0	53
Javier	1	2	3	12	0	0	4	0	3	0	1	1	4	2	5	0	1	39
Kristina	0	2	1	1	4	0	1	3	2	0	0	0	0	0	3	2	2	21
Justin	0	1	0	2	1	5	0	0	0	0	0	0	3	0	0	0	1	13
Jamie	0	0	0	3	1	0	0	2	0	0	0	1	3	0	0	0	1	11
Steven	1	0	0	4	1	3	1	1	0	0	5	1	4	3	6	4	2	36
Mia	0	0	1	7	0	0	0	0	1	0	0	0	0	2	0	3	0	14
Adriana	0	0	2	2	2	1	1	0	0	0	0	1	1	2	2	3	0	17
Alex	0	0	3	0	0	3	1	0	0	0	1	2	0	1	1	0	0	12
Stacy	0	0	1	1	2	0	2	0	1	0	0	0	2	1	0	0	0	10
Jacob	1	0	1	5	1	0	0	0	0	0	0	0	0	0	0	0	2	10
Colby	0	1	2	2	3	0	0	0	moved									8
Michael	0	0	1	3	8	2	1	moved										15
Todd	0	0	0	0	0	0	0	2	1	0	2	0	2	0	0	0	0	7
Chris	3	0	0	5	3	5	8	0	3	2	2	3	4	2	7	7	2	56
Aaron	3	2	1	8	3	0	0	3	2	0	4	3	6	9	5	8	0	57
SUMMARY	14	19	22	85	44	31	36	20	25	6	27	20	37	31	37	38	14	506

Data Summary Table: Finding 3 SG Exploratory Talk

Note: Week 3 and 4 were combined
No small group during week 12 (wrap-up week)

X=no week 1 data for group 4 (taping malfunction)
(#)=group number

Student with group #	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	TOTAL
Madison (1)	2	2	7		9	3	6	5	4	4	7	49
Ivan (1)	0	0	0		0	0	5	0	0	0	0	5
Megan (1)	2	4	0		6	5	3	7	0	7	12	46
Alvin (1)	1	0	4		1	6	1	2	10	2	0	27
Tiara (1)	3	4	3		8	0	5	0	4	16	14	57
Kara (1)	0	3	9		3	2	3	6	2	4	2	34
Javier (2)	6	1	3		10	3	1	0	2	6	31	63
Kristina (2)	2	5	1		1	2	4	8	3	11	23	60
Justin (2)	9	1	4		0	3	0	3	0	12	0	32
Steven (2)	4	0	7		8	5	10	8	3	6	6	57
Jamie (2)	2	3	2		1	0	0	1	0	0	1	10
Mia (3)	0	1	3		3	3	4	6	0	9	11	40
Adriana (3)	0	2	2		10	4	2	6	2	16	9	53
Alex (3)	6	0	6		9	0	5	4	2	10	14	56
Stacy (3)	2	2	4		2	2	1	2	3	10	4	32
Jacob (3)	3	1	0		0	0	0	0	0	0	0	4
Colby (4)	X	1	2		14	moved						17
Michael (4)	X	0	10		moved							10
Todd (4)	X	0	8		0	3	7	5	4	12	7	46
Chris (4)	X	2	12		9	2	14	35	4	26	7	111
Aaron (4)	X	2	14		19	4	25	40	3	20	24	151
SUMMARY	42	34	101		113	47	96	138	46	171	172	960

Data Summary Table: Finding 3 Other Exploratory Talk

	Observation #1	Observation #2	Observation #3	Observation #4	Observation #5
Madison	1	1	1	0	0
Ivan	0	0	0	0	0
Megan	0	0	0	0	0
Alvin	0	0	0	0	0
Tiara	0	0	0	0	0
Kara	0	0	0	0	0
Javier	0	0	0	1	0
Kristina	0	0	1	0	0
Justin	0	0	0	0	0
Jamie	0	0	0	0	0
Steven	0	0	0	0	0
Mia	0	0	0	1	0
Adriana	0	0	0	0	0
Alex	0	0	0	0	0
Stacy	0	0	1	0	0
Jacob	0	0	0	0	0
Colby	0	0	0	0	0
Michael	0	0	0	0	0
Todd	0	0	0	0	0
Chris	0	0	0	0	0
Aaron	0	0	0	0	0
SUMMARY	1	1	3	2	0

APPENDIX M

Data Summary Table: Finding 6

Teacher Support

Data Summary Table: Finding 4: Teacher Support

Descriptor:	TOTAL	Whole group	Small group	Other
Open-ended questions	**561**	248	313	0
How	210	82	128	0
What	178	92	86	0
Why	150	61	89	0
I wonder	23	13	10	0
Reply not assess	**1306**	522	784	0
Okay	1028	410	618	0
Oh	212	95	117	0
Well	66	17	49	0
Review (problem, ideas, model)	**190**	46	144	0
Problem	105	19	86	0
Idea	60	12	48	0
Model	25	15	10	0
Lead through puzzlement	**103**	57	46	0
Teacher as peer	**105**	48	57	0
Informal use of vocabulary	**96**	31	65	0
Tools	**46**	25	21	0
Revoice:	**677**	362	315	0
Statement	450	213	237	0
Question	176	98	78	0
Written revoice	51	51	0	0

APPENDIX N

Data Summary Tables: Finding 7

Social Norms

Data Summary Table: Finding 5: Social Norms

Descriptor:	# of utterances	Whole group	Small group	Other
Ideas	**618**	351	266	1
Talking	127	83	43	1
Listening	23	15	8	0
Thinking	59	33	26	0
Different ideas okay	101	64	37	0
Show/represent ideas	119	29	90	0
Building ideas	76	53	23	0
Understanding others' ideas	77	52	25	0
"Anybody have an idea?"	36	22	14	0
Conflict:	**48**	31	16	1
Fairness	23	14	9	0
Puzzlement	11	4	7	0
Friendship	14	13	0	1

Data Summary Table: Finding 5: Social Norms (cont'd)

Descriptor:	TOTAL	Whole group	Small group	Other
Problems:	**308**	150	153	5
"Problem solve"	117	75	41	1
Real life problems	28	15	9	4
Problems are . . . [good, exciting tricky, yummy]	51	36	15	0
"Investigate/find out"	102	19	83	0
Mistakes okay	10	5	5	0
Old norms	**81**	53	27	1
Shared Decision Making:	**1066**	411	647	8
Agree	251	81	170	0
Choices	14	6	8	0
Voting	70	39	31	0
"What do you think?"	179	80	99	0
"What could we do?"	74	32	42	0
Group not teacher decides	281	80	197	4
Teamwork	163	65	94	4
Talking about talking about decisions	34	28	6	0

APPENDIX O

Coding Scheme Development Chart

Developmental Phases of Coding Process	Description of Coding Process
(1) Coding process step 1: Oct. 2007 After conducting a literature review on exploratory talk, I developed an initial literature-based coding framework for the dissertation proposal.	This coding examined presentational talk, exploratory talk, and other types of talk present in classroom math discourse and was based on the research of Barnes (1992) and Mercer (1995).
(2) Coding process step 2: May 2008 Began initial coding of transcribed data into three types of talk.	Found that some types of talk were difficult to code and did not fall into the three categories. Additionally, the framework seemed too shallow and did not provide insight into the study's research questions.
(3) Coding process step 3: August 2008 A revised coding framework was developed based on an ongoing literature review, informal analysis as well as anticipated findings. Categories are directly linked to the study's five research questions.	Through examination of students' exploratory talk utilizing the video tape transcripts, I discovered that gestures and modeling the idea accompanies some talk. Added a sixth category and descriptors to conceptual framework.
3) Coding process step 4: September 2008 While coding using the conceptual framework, additional themes emerge and are added to the schema.	Found that the category "Support" was too general—needed more information to code accurately. Separated "Teacher Support" from "Peer Support." Teacher Support will include: "Probing questions", "Reply not assess", "Think time", and "Other." Under Peer Support, descriptors include "Co-construction" and "Other." Four new descriptors are added under Social Norms: "Different ideas okay", "Joint consideration", "Active engagement with ideas", and "Challenge ideas."

4) Coding process step 5: October 2008 Further refinement of conceptual framework.	Added descriptor “Revoice” to Teacher Support. This eliminated the descriptor “active engagement with ideas” in Category 5. Changed this to “Check for understanding.” Found that two descriptors were overlapping, including “Build on others’ talk” (Category 5) and “Co-constructions”(Category 7). Referred to Cobb et al. (1993)’s findings on “talking about talking about mathematics” (teacher talk) and “talking about mathematics” (peer talk). Talking about talking about building on others’ talk will go in Category 5 as Cobb et al. found that such talk can lead to new social norms. Actual discourse demonstrating such talk will be labeled Peer Support (Category 7).
5) Coding process step 6: October 2008 Conceptual framework reformatted	Found some overlap between the descriptor “Probing questions” (Category 4) and “Challenging ideas” (Category 5). Noted that both teacher and peers can challenge others’ ideas as they exchange points of view, which may enable a student to decenter (Kamii, 2000b). Eliminated “Challenging ideas” from Social Norm category. Added it to Category 7: Challenging ideas.
7) Coding process step 8: October 2008 Further refinement.	Found overlap between descriptor “Probing questions” (category 4) and “Seek to understand idea” (category 5). Probing questions can include those questions that teacher (or peer) already knows—more of a scaffold. “Seek to understand idea” is more open-ended—teacher honestly seeks to understand idea from student’s viewpoint.

8) Coding process step 9: October 2008 Further refinement of category "Mathematical Reasoning" (Category 1) is needed.	Found that mathematical categories needed refinement. Referred to recommendations by NCTM (2006) as well as Sarama & Clements (2006b) on what concepts should be taught in Kindergarten mathematics. Added descriptors under each math category.
9) Coding process step 10: November 2008 Probing Questions (Category 4) is becoming too large, necessitating refinement of descriptor.	Further analysis of descriptor: "Probing Questions" reveals that a large percentage of the questions are what Cazden (2001) terms 'inauthentic' as I had an answer in mind. Lindfors (1999) considers such questions as information-seeking. She suggests that they tend to close rather than extend inquiry. Teachers should utilize open-ended questions that support children's emergent inquiry. The descriptor will be retitled "Open-ended Probing Questions." Inauthentic, presentational discourse will be eliminated from coding as it does not support exploratory talk (Barnes, 1992; Cazden, 2001; Lindfors, 1999).
10) Coding process step 11: November 2008 Saturation of one descriptor in Category 4.	Found that one descriptor cannot be split, namely "Reply Not Assess." Discourse will be coded as such in the complete lesson transcription (and tallied on the data summary sheet) but will not be added to the chart due to saturation unless evidence of a new pattern or theme emerges.
11) Coding process step 12: November 2008 Descriptors need to be further defined.	Found that descriptor "Joint consideration" (Category 5) needs to be further refined. Changed title to "Shared decision-making." Also two descriptors were overlapping: Open ended probing questions (Category 3) and Shared decision-making (Category 5). Classification was made after reviewing the findings to date. Open ended probing questions tend to begin with "how", "why", or "I wonder" (Lindfors, 1999). Shared decision making, while using some probing questions, are ideas presented for group involvement in making decisions.

12) Collapsed descriptor “Misunderstandings.” November 2008	Data summary sheets revealed few utterances in the descriptor “Misunderstandings” (Category 5). Found that some of the utterances could be moved to “Conflict” or “Seeking to understand others’ ideas”, thus eliminating the descriptor.
13) Further refinement of framework: December 2008	The coding schema becomes more streamlined due to the combination of descriptor “Joint Agreement” with “Shared Decision Making” (Category 5). Through analysis, found that “Working as a team” (Category 5, descriptor “Other”) could be combined with “Shared Decision Making” (Category 5).
14) “Other” categories becoming too large, requiring further refinement and collapsing of some descriptors: December 2008	Am finding that the “Other” categories are becoming difficult to manage. Reexamined each chart in detail, repositioning utterances as initial findings emerged. Under Category 4, new descriptors emerge including: “Tools”, “Teacher as peer”, “Review”, and “Lead through puzzlement.” Under Category 5, new descriptors include: “Old norms”, “Problems”, and “Behavior.”
15) A descriptor is overly detailed: December 2008	Found that “Explanations” (Category 5) was too defined. Retitled it “Ideas”, allowing me to combine it with “Different ideas are okay”, eliminating that descriptor from the framework.
15) Two descriptors/categories are overlapping: December 2008	Descriptor “Explaining ideas” (Category 5) and “Exploratory talk” (Category 3) are overlapping. As explaining ideas is a component of exploratory talk, will remove such descriptor from the coding schema.
16) Further refinement of the definition of exploratory talk: January 2009	Found overlap between examples of exploratory talk and the category “Peer Support.” Peer support IS exploratory talk (Barnes, 1992; Mercer, 1999); thus the category will be removed from coding. Any utterances that are short replies without explanations (i.e., “No!”, “Yeah!”) will be eliminated as they do not support student talk (Barnes, 1992; Mercer, 1995).

	Those with explanations will be coded as examples of exploratory talk.
17) Mathematical errors need further refining. Found some mathematical understandings that talk about the concept (do not actually demonstrate the concept): January 2009.	Found that mathematical errors need to be further defined. Thus, all errors will be coded with the regular mathematics coding followed by an "E" for error. For example: MNumber2E stands for error in object counting. This eliminates descriptor "Error" (Category 1). Also am finding some mathematical discourse that includes talking about the concept, such as sharing an idea using object counting. It does not show students engaged in object counting but IS mathematical understanding. Will code such utterances with a "T" to signify finding.
18) New descriptor needed: January 2009.	Under "Other" in Category 5 (Social Norms), found utterances containing "strategy", "predict", and other mathematical terms used informally. Added new descriptor to Social Norms: Informal use of math language.
20) Some discourse difficult to code, requiring clarification of descriptors: January 2009.	Again, closed questions are causing difficulty. For example, "Did we find the right number of tails?" is a closed question as the response is either yes or no and does not lead to explanations (Lindfors, 1999). However, it could be coded as either "Seeks to understand others' ideas" OR "Joint decision making." Through analysis, such questions would be better voiced as an open-ended probing question (Lindfors, 1999). For example, "What did we find out about the number of tails?" is open-ended and leads to explanations thus furthering exploratory talk. Thus, <u>all</u> closed questioning will be removed from coding as it does not truly support exploratory talk.
22) Exploratory talk reveals more than just mathematical understandings and irregular speech: January 2009.	During final analysis, find that Category 2: What does exploratory talk sound like? emphasizes only the speech disfluencies and doesn't showcase the emergence of students' reasoning abilities

	and their progress with exploratory talk. Added descriptors to conceptual framework draw from students' talk, including: sharing of ideas, theory building, demonstrates, statements offered for joint consideration, request for explanation and clarity, ideas may be challenged but justified, alternative theories presented, joint agreement, using evidence, sets up hypotheses, and reaches conclusions (Mercer, 1995).
23) Analysis reveals some descriptors need to be combined, moved, added, or eliminated: January 2009.	A review of utterances reveals the following: • Descriptor "Seeking to understand others' ideas" fits with "Ideas" (Category 5); thus collapsing the first descriptor into the second. • Descriptor "Informal use of vocabulary" is actually a form of teacher support (Chapin et al., 2003) and should go under Category 4. • Descriptor "Behavior" is too defined; retitled it "Talk/Listen." • Identified new descriptor "Thinking" in student utterances in "Miscellaneous" category. As these represents a social norm (Cobb et al., 1993), will collapse the descriptor "Think time" under Category 4 "Teacher Support" and combine it with "Talk/Listen" (Category 5). • Found some evidence of old norms. Add to Category 5.
24) Found a few inconsistencies in Data Summary Tables: January 2009.	Due to the evolving nature of the research process, I identified a few inconsistencies such as how many exploratory talk utterances each participant had. I assembled a set of index cards for each participant, noting the occurrence of exploratory talk, the week, and where it occurred. I then examined each utterance, recording what was present in the talk.

	This allowed me to cross-reference the data sources to ensure that my findings were credible.
25) Review of charts: February 2009.	Found that the “Other” descriptor under Category 2 is overlapping. Will combine “Shares thinking” with “Explanations”, collapsing Explanations from the conceptual framework. Also overlap between “Demonstrates” (Category 2) and Descriptor “Models/represents” (Category 6). After examining the utterances, found majority could be placed under “Demonstrates”. Note that the remaining ones utilize use of fingers; added “Uses fingers” as a new descriptor under Category 6. Found that “Demonstrates” can be combined with “Uses Evidence”, collapsing “Demonstrates” from the framework.
26) Final review: February 2009.	Under Category 5 (Social Norms), talk/listen/think are actually utterances where students talk, listen, listen or think about IDEAS! Will put this with Category 5.

APPENDIX P

Consistency Charts

Consistency Chart

Findings	Interpretations	Conclusions
Number and operations were found in the majority of the utterances. Talk related to measurement was also found in a small amount of mathematical exploratory talk followed by data analysis, geometry, and algebra . Majority of participants shared problem-solving strategies that involved number. A small amount of errors were identified with the largest amount found in talk related to number and operations.	1. Students rely on number to solve problems, including sharing ideas involving number. 2. The problems introduced emphasized number over other concepts. 3. Students had difficulty with adding and taking away and object counting. 4. Some students were not at cognitive levels to complete some strategies needed for adding and taking away and object counting.	The participants' exploratory talk included an overwhelming amount of concepts related to number. NCTM (2000) finds that young children's earliest reasonings involve number situations. Children typically rely on their understanding of number to solve problems. Other mathematical concepts, while found in some of the exploratory talk, still, to a large extent, related back to number (i.e., group 4's idea of comparing animals using number). Students' math talk also includes errors. Counting on has been found to be difficult for some five and six year olds because they have not constructed the logic of addition (Kamii, 2000). Some of the errors emphasized centration (Madison's view that one object was longest because it had the most), indicating cognitive differences in students in the classroom.
The overwhelming majority of participants had speech disfluencies in their exploratory talk.	1. Speech disfluencies indicate that the students are "thinking out loud", forming ideas while talking. 2. Some exploratory talk becomes clearer the more students interact with peers and teachers. 3. Students use speech disfluencies all the time.	A conclusion that can be drawn from this finding is that when students engage in exploratory talk, they are forming ideas while talking, resulting in utterances that are not well articulated in an attempt to be understood by others, namely their peers. This results in what Cazden terms "cognitive load" (p. 170).

Consistency Chart

Findings	Interpretations	Conclusions
All 21 participants shared their ideas through exploratory talk. The overwhelming majority offered statements for joint consideration. The majority challenged, set up hypothesis, requested clarity, and had joint agreements. Some used evidence, drew conclusions, provide alternate theories, and revised their thinking.	1. When students exchange ideas with peers, they have to decenter in order to explain their thinking. 2. When students are challenged by their peers, their logic may increase. 3. This can impact future ideas.	Exploratory talk sounds like students exchanging ideas that leads to continual refinement of ideas, impacting future ideas. Piaget (1950) found that when students exchange ideas and have mutual control, their logic improves. Perret-Clermont (1980) and Doise-Mugny (1984) verified this, finding that when students have opportunities to agree, disagree, and convince each other, they demonstrated higher-level thinking. While others are not a source of logico-mathematical knowledge, they can cause children to reexamine their own thinking as evidenced by students' abilities to provide alternate theories and revise their thinking found in the data. Findings suggest a cyclical nature to exploratory talk.
The majority of participants had hand movements that accompanied their exploratory talk, including pointing and dramatization. Some participants used fingers to solve problems.	1. Students use gestures to add meaning to their exploratory talk due to limited vocabulary, including pointing and dramatization. 2. Use of fingers aids students with mathematical thinking.	One conclusion is that young children have developing vocabularies resulting in the need for gestures to add meaning to their math talk. Other researchers have found that young children have difficulty explaining their mathematical thinking, indicating a gap between mathematical ability and verbalization (Schwartz & Brown, 1995). In addition, students' use of fingers are a tool they use to solve mathematical problems. Kamii (2000) found that students prefer fingers over counters. She writes "fingers are symbols used in the service of thinking."
A large amount of exploratory talk utterances were found. All 21 participants engaged in exploratory talk during small group and whole group activities. A small number of students had examples of exploratory talk during observations, including calendar, math activities, snack preparation, and a class meeting.	1. Students engage in exploratory talk in different formats. 2. Whole group discussions support small group discussions.	One conclusion is that children engage in exploratory talk when they have opportunities to exchange points of view. Their exploratory talk is supported by their peers, the teacher, and classroom norms.

Consistency Chart

Findings	Interpretations	Conclusions
Much of the teacher support was the use of reply not assess statements. Some included revoice and open-ended questions. A small amount included review, teacher as peer, leading through puzzlement, math vocabulary, and tools.	1. Teachers can facilitate exploratory talk through various support systems that extend, rather than limit, student thinking. 2. Teachers can guide conversations as they step in and out of the dialogue. 3. Teachers can act as inquiry guides.	Teachers can support the use of exploratory talk in the classroom through various means, including: reply not assess statements. When students are judged on their answer, this in fact "shuts down" the thinking process, giving control back to the teacher. When the teacher however replies to a student's answer without judgment, there is shared control. Through revoicing, students' answers are affirmed, whether through a statement, a question, or a written revoice. Open-ended questions extend the thinking process rather than shutting it down with a closed response (Cazden). Through review, the teacher focuses attention on the problem. When acting as a peer, the teacher engaged in exploratory talk with the students and at times, leads them through, not out of, their puzzlement. In conclusion, the teacher acts as an inquiry guide, stepping in and out of the classroom dialogue.
The majority of social norms found in the classroom emphasized shared decision-making. Some were related to ideas. A small amount referred to problems. A few others reflected old norms and conflict.	1. The teacher shared control of the classroom with the students. 2. Students and the teacher thought out loud. 3. Problems were viewed as something to work through together. 4. Changing classroom norms is a process and takes time. 5. Conflict occurs in the classroom and can be used as a learning experience.	As students and the teacher exchange ideas, they are collectively building a classroom environment that supports thinking and reasoning. The teacher is no longer the beacon of knowledge. Rather, students are viewed as members of a learning society. Talking, listening, and representing ideas becomes the norm. Problems are something to be desired in such a community of learners. Changing classroom norms takes time as students come with preformed views of the classroom. However, the end result is one of a caring community where students and the teacher alike can talk and learn together mathematically.

VITA

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Candidate for the Degree of

Doctor of Education

Dissertation: KINDERGARTEN STUDENTS' EXPLORATORY MATH TALK WITHIN A COLLABORATIVE DISCOURSE COMMUNITY

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Scope and Method of Study: This qualitative teacher research study examined what is revealed in Kindergarten students' exploratory math talk. In addition, classroom discourse was analyzed to provide an understanding of the social context affecting the research. Three data collection methods were employed, including audio recordings, video recordings, and observations. Participants were twenty-two students in the teacher researcher's classroom from a large Midwestern urban school district. Data were analyzed to reveal trends in the classroom discourse.

Findings and Conclusions: A central research finding was that the majority of exploratory talk was related to mathematics, specifically to number and operations. Other mathematical concepts were found to a lesser degree. A primary conclusion was that students relied on their understanding of number to solve problems. Additionally, analysis revealed students exchanging ideas with others, struggling to form their thoughts while speaking. These articulations were difficult to understand at times and were often accompanied by gestures and the use of fingers. As ideas were exchanged and challenged, the students' own thinking was modified, suggesting a deeper understanding of the concept. Supporting these exchanges was an evolving collaborative environment as evidenced by the social norms. The teacher acted as an inquiry guide, stepping in and out of the discourse to support the students' dialogue. The researcher concluded that exploratory talk promoted the construction of a collaborative discourse community ripe with mathematical learning.

This research may be of interest to other educators as it portrays a journey of change—of putting into place constructivist theory into the real world of the classroom. Old behaviorist norms had to be overturned and were still found in some of the discourse. As the teacher and the students struggled with transformation, an emergence began—one that revealed the interplay between students' individual mathematical development intertwined with the social activity of mathematics. Supporting this emergence was the framework of exploratory talk which enabled the teacher to provide opportunities for students to exchange ideas, challenge, and modify their existing thinking.

ADVISER'S APPROVAL: Dr. Kathryn Castle