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DECISION-MAKING IN A COACHING ENVIRONMENT: HOW A COACH MAKES DECISIONS WHEN COACHING A MATHEMATICS TEACHER ON STUDENT/TEACHER DISCOURSE

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By

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DISSERTATION

Submitted in Partial Fulfillment of the
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Dedication

I dedicate this dissertation to my family:

       my husband who has supported my work over many years,

       my son whose perseverance inspires me,

       my daughter whose determination sets an example for me,

       and my grandchildren, Kelsie, Augustus and Viola who make me smile.

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ABSTRACT

The purpose of this study was to determine how a mathematics coach made decisions when coaching a middle school mathematics teacher on using classroom discourse in a reform mathematics classroom. This was a researcher participant qualitative study using design experiment methodology in which the coaching process was studied in an environment that is typical of an educational coaching setting. The teacher and coach/researcher made conjectures on what was happening in the classroom based on observations; the conjectures provided the basis for the development of the interventions. The teacher modified her pedagogy using the interventions; the results of the pedagogical changes were discussed as the teacher and coach engaged in discourse in the coaching sessions. The process was repeated four times over an eight-month period. In this study, the researcher found that the coach's decisions were based on the teacher's current beliefs and practice, the relationship between the coach and the teacher, and current educational research

related to the topics addressed in the coaching sessions. Finally, implications for the

coaching process are discussed.

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CHAPTER 1

INTRODUCTION TO THE STUDY

This dissertation is a report of a qualitative study of how a coach makes decisions when coaching a mathematics teacher on the use of discourse in the classroom. The study was based primarily on the discourse that took place between the coach and the teacher and classroom observations. The first chapter of the dissertation presents the background of the study, describes the problem of the study, describes its significance and presents an overview of the methodology used. The chapter concludes by noting the delimitations of the study and definition of key terms.

Background of the Study

This section will include the following developments in education that influenced this study: Coaching as a means of professional development, reform mathematics, discourse and decision-making.

Coaching as a Means of Professional Development

Coaching is a professional development method used in education as a means to improve teacher practice and improve student learning (Poglinco & Bach, 2004). Teacher performance is key to improving student achievement; however, identifying what types of educational experiences and professional development activities result in improved teacher performance that increase student achievement has eluded the research community (Marzano, 2003; Rivkin, Hanushek, & Kain, 2005). In his research on highly effective schools that serve the poor, Kitchen (2007) found that teachers in the participating schools were regularly involved in professional development. Yet, neither has it been shown that professional development impacts student learning, nor has it been shown that it has no

effect. Professional development continues to hold a prominent position in reform efforts designed to improve education (Borko, 2004; No Child Left Behind Act of 2001, 2001).

Within this overarching approach to school improvement, there are numerous professional development models that organizations enact with the goal of changing current practice and improving student achievement in an effort to reform education. Shulman (2004), described school reform as an ellipse with two foci—one was student learning, and one was teacher learning, each informing the other. While teacher learning affects student achievement, student achievement informs teacher learning in a recursive process. Teacher learning is a dynamic process, changing to meet the needs of students. Coaching as a professional development model can further teacher learning, learning that is essential to help a teacher implement practices that reflect a reform mathematics approach.

Reform Mathematics

The publication of "An Agenda for Action: Recommendations for School Mathematics of the 1980's" (National Council of the Teachers of Mathematics, 1980) was a document credited by the mathematics community as initiating the movement to substantially change the way mathematics was to be taught. This document altered the emphasis from getting one right answer to one that emphasized the process by which students came to understand mathematics. Teachers struggled to implement the standards because their curricular materials did not align with the standards (Klein, 2003), and the teachers did not know how to be successful in teaching to the new standards (Darling-Hammond, 1997). Discourse between students and teacher and among students is a way to explore mathematics in an effort to understand the concepts.

Discourse

When learning occurs through human interaction using mediating factors including speech and objects, students learn from interacting with the teacher and each other as they try to make sense of an engaging task (National Council of the Teachers of Mathematics, 1989, 2000; van Oers, 2002; Vygotsky, 1978). Each person brings her experiences, culture, abilities and viewpoints to the learning environment. While the discourse can result in gaining understanding or questioning what was previously thought to be known, the goal of a learning situation is to move the learner from the current level of understanding to a higher level through the interaction with a more knowledgeable other (Sfard, Forman, & Kieran, 2002; Vygotsky, 1978, 1986). Discourse is viewed as an essential component of the learning process in reform mathematics as a means to learn with understanding (Forman, 2003; National Council of the Teachers of Mathematics, 1989, 2000). The coaching process requires the coach to make decisions on moving a teacher forward in her practice by developing her ability to use discourse as a means to help students explore the mathematics.

Decision-making

Coaching is a method of continuous professional development for teachers who have been shown to make a significant impact on student learning (Joyce & Showers, 2002). While there are numerous models for coaching, how coaches make decisions concerning the most effective and productive ways to improve teaching performance in relationship to identified standards has not been a central focus of the research I uncovered. Information regarding decision-making by a coach has the potential of increasing the overall effectiveness of coaching models.

Problem Statement

Coaching as a means to provide continuous professional development is a complex process because of the many variables present when working with a variety of people (Ball & Cohen, 1999). Examples of variables include teaching experience, receptivity to change, content knowledge, pedagogical content knowledge, teaching style, personality, beliefs, and school environment. Coaches make decisions before and throughout the coaching process as they attempt to provide the most beneficial experience for the teacher considering all the variables. This led me to ask the research question: How does the coach make decisions when coaching a middle school mathematics teacher on classroom discourse?

Professional Significance of the Study

This research is important because it provides information on ways of making decisions as a coach works with a teacher in a way that promotes student understanding of mathematics through discourse with each other and with the teacher. While there are multiple coaching models that have been developed, ways of making coaching decisions in the coaching setting has not been a primary focus in research studies I have uncovered; rather, decision-making was referred to when the data analysis of student achievement indicators (Anstey & Clarke, 2010) were used to determine subject matter areas where students were not proficient thus informing the coach and teacher where pedagogical changes could influence student achievement. Identifying how the teacher used discourse to facilitate and assess student learning guided me as I made decisions on the content of coaching sessions. The next section describes the methodology used in the study.

Overview of Methodology

In this section, I give a brief description of the methodology I employed in this study. A more detailed account is presented in chapter 3.

This research employed a qualitative research approach as a way of deeply exploring the complexity of the decision-making process in a coaching setting. The research was embedded in the environment in which the coaching and classroom instruction took place as a way to explore ways a coach made decisions in a setting that is typical of schools (Sfard, 2002). The qualitative method used was *design experiment.* This approach was especially useful in doing research in an educational setting because there were so many variables. Additionally, the research employed the use of conjectures as a way to anticipate what might happen, followed by observation, then analysis of the data.

The data was compared to conjectures and used to determine appropriate interventions. The analysis of the data was based on Strauss and Corbin's (1998) systematic approach to data analysis. It began with open coding where data was analyzed line by line, then the analysis moved to axial coding where categories emerged. Finally, selective coding was used to analyze the categories to formulate generalizations. Transcripts of the classroom lessons and the coaching sessions provided the means to look for patterns and explanations, make conjectures, design interventions and explore the coach's decision-making process. While the study shed light on the decision-making process, there are delimitations of the study that are addressed in the next section.

Delimitations of the Study

To understand where this study resides in the general corpus of educational research, it is informative to do a formative assessment of this design experiment. I will discuss replicability, design issues, and data analysis.

Replicability

It would be difficult to replicate the study as the setting was unique. It was in a small private school whose director was a university math professor and many of the students were English Language Learners at the time of the study. Additionally, the coach had extensive experience in education having been a mathematics teacher, principal, and director of curriculum, and was also a doctoral candidate. Few content-focused coaches will have had that level of experience and education.

Design Issues

The study was limited in that there was only one participant other than the coach/researcher. While the teacher was not a certified teacher, she had worked with a university professor and had taught mathematics for five years but, arguably, the decisions made by the coach could have been different if the participant had been a certified mathematics teacher. Having additional teachers from other schools in the study would have provided more data on which to base the generalizations. While member checking occurred in the coaching sessions, a journal kept by the teacher would have given a more detailed viewpoint of the participant's experience.

Data Analysis

The teacher struggled to find time to spend on reading and reflecting on what occurred in the observed lessons. I would have liked to spend more time with the teacher to

analyze the classroom observations together as a way to explore underlying meanings of her utterances, patterns of discourse, and intentions she had for her comments in more depth.

As the coach, I struggled to focus on the decision-making aspect of the research question and would often use the analysis of classroom observations and coaching sessions to assess the responses to coaching sessions. I continually had to remind myself to use the analysis as a way to determine why and in what ways I was making coaching decisions. Ultimately, the research provided information useful to the educational community to fulfill the need for continual professional development to its practitioners. The next section includes definition of terms used in the study.

<div align="center">**Definitions of Terms**</div>

This section includes definitions of terms as they are used in this study as a means to enhance the reader's understanding of the research.

Constructivism: Constructivism is an approach to learning with the learner is centrally located as an active participant in making sense of concepts with a teacher who serves as a facilitator rather than a conduit for knowledge (Forman, 2003; Forman & Ansell, 2002). While the teacher may serve as a catalyst for learning, how students make sense of the tasks through dialogue with their peers and their inner dialogue is particularistic. Prior knowledge and experience provide the building blocks that inform ways students approach learning and help them make connections to new knowledge.

Sociocultural theory: In the sociocultural perspective, learning is developed through socially supported interactions (Vygotsky, 1978). Learning and child development is brought about through communication.

Discourse: Discourse in this study was defined as little "d" discourse (Gee, 2005), language-in-use, where language is used as a means to enact activities and identities. In this empirical research study, discourse is seen as; (a) constitutive, (b) functional, and (c) co-constructed (Ryve, 2011).

Emergent perspective: The emergent perspective combines constructivism and sociocultural theory. Constructivism is more individually oriented in which knowledge is developed organically based on their experiences and previous knowledge (Stephan, Bower, Cobb, & Gravemeijer, 2003). Responsibility for the learning resides with the individual whereas the sociocultural perspective views learning as a social interaction where learners interact in an attempt to make sense of the mathematics. In the emergent perspective, individual learning and social learning are not viewed as dichotomous but rather students bring their individual knowledge and experiences to the social setting where they are shared with others to form a new understanding.

The next section summarizes the information in the chapter and describes the organization of the remainder of the dissertation.

Summary

The confluence of reforms in mathematics education and the realization that continuous professional development was needed to support systemic change stimulated my interest in exploring coaching as a way to provide that continuous professional development. Discourse was an important aspect of teaching for understanding as a means to help students uncover and make sense of mathematical concepts and a means by which the teacher supported and guided student exploration. The aforementioned aspects of teaching mathematics coalesced resulting in my research project.

This chapter described the background of the study, the problem of the study, and its significance and presented an overview of the methodology used. The chapter then concluded by noting the delimitations of the study and definition of key terms. The remaining chapters of this dissertation include the literature review, a detailed account of the research methodology, data analysis and finally, discussion and generalizations.

CHAPTER 2

LITERATURE REVIEW

This chapter includes a literature review of the theoretical literature on constructivism, sociocultural theory and adult learning theory. It then reviews the research literature on reform mathematics education, coaching, change and moving educational research to practice. Included in this review are prescriptive and empirical studies that shed light on the aforementioned topics as a way to make sense of the complexities of making decisions in a coaching environment. This literature review will reveal that, while much is known about aspects of teaching mathematics, decision-making with respect to a coach as she interacted with a teacher was not evident in articles uncovered in the literature.

Theoretical Literature

The theories that informed this research study included constructivist theory and sociocultural theory that undergird how mathematics is learned in the classroom. Additionally, constructivism, sociocultural theory and adult learning theory applied to ways a teacher and coach learned from each other in a coaching environment.

Constructivist Theory

Constructivist theory is a learning theory in which knowledge is created by building on past constructions (Sackney & Mergel, 2007). New experiences create a cognitive dissonance and the learner seeks to resolve that dissonance by assimilating and accommodating the new information with past constructions. New knowledge is an invention not an accumulation of information independent of what was previously known.

The roots of constructivist theory resided in the work of Dewey, Piaget and Vygotsky (Sackney & Mergel, 2007). Dewey (1940) thought that education should be based on

activities that reflected the complexities of life, not be an accumulation of information presented by a teacher. Piaget (Piaget & Inhelder, 1969) viewed learning as mainly biological in nature; learning occurred as an individual connected new knowledge to what was already known as they matured. Vygotsky (1978) emphasized that human beings learn by interacting with a more knowledgeable other. This construct was termed the zone of proximal development; an individual can perform tasks independently but can also perform tasks with the help of others. This level of performance that can be achieved with help will vary by individual and is more than imitation; it is developed through external representation and, with reflection eventually becomes internalized. Vygotsky is also associated with sociocultural theory.

Sociocultural Theory

Communication, more specifically discourse between human beings, is a means of making sense of academic disciplines and is central to the sociocultural theory of learning (Sfard et al., 2002). In the sociocultural perspective, learning is developed through socially supported interactions (Vygotsky, 1978). Learning and child development is brought about through communication. As Vygotsky (1978) stated, ". . . the most significant moment in the course of intellectual development, which gives birth to the purely human forms of practical and abstract intelligence, occurs when speech and practical activity, two previously completely independent lines of development, converge" (p. 24). From this perspective, cognition is inherently social and learning is viewed as an element of a system of cultural practices (Cobb, 2007).

Vygotsky advocated that we not only look at mental activity but at situated practices; and that the process must be studied, not just the outcome of activities (Forman, 2003;

Vygotsky, 1978, 1986). Thus, sociocultural theory provides a means to explain the complex relationship between social context and learning. Adult learning theory reflects the importance of the learner's position in relationship to the knowledge they possess and that which is to be learned.

Adult Learning Theory

Andragogy is an organizing concept used to describe the ideas explaining adult learning (Brookfield, 1986; Knowles, Holton III, & Swanson, 2005). The six assumptions that make up the andragogical model are (1) need to know, (2) learner's self-concept, (3) experiences, (4) readiness to learn, (5) orientation to learning, and (6) motivation. The theories that inform this model are constructivism and sociocultural theory.

Assumptions. The andragogical model is based on the following six assumptions. First is the *need to know*—as adults, a reason for learning motivates adults to exert the energy and spend time needed to learn. Second, the *learner's self concept* is such that they want to be viewed as capable of self-direction and not be treated as children who need to be told what they need to learn. Third is the role of the adult learners' *experiences* and how those experiences inform them as they relate to what is to be learned. The valuable, relevant experiences of participants can be a resource in the learning environment if their experiences are incorporated in the learning process. Some experiences can negatively affect the learning if ideas have become fossilized resulting in a close-minded approach that bars consideration of new ideas. Fourth is the *readiness to learn* which combines a need to know with a desire to be able to do something that is needed in real-life situations. For example, exposure to better, more productive teaching techniques may evoke a readiness to learn in a developing teacher. Fifth is the *orientation to learning* where adults view the need to learn from a

perspective of how it fits into and can improve their life situations. Sixth is *motivation*— which can be external or internal. External motivators can include the desire for a job promotion, higher pay, different job. Internal motivators are more powerful than external motivators and include increased self-esteem, quality of life, personal satisfaction. Adult learning theories were based on constructivism and sociocultural theory.

Theories and adult learning. As educators considered what experiences would serve to improve teacher performance, analyzing the characteristics of learning opportunities can identify salient characteristics of professional development models. Learning experiences based on constructivist models and aspects of sociocultural learning, including discourse among learners, are an integral part of the andragogical model.

Constructivism builds on learner prior knowledge and experience, viewing learning as a problem-solving process, making meaning through discourse, and taking responsibility for one's own learning (Aseltine, Faryniarz, & Rigazio-DiGilio, 2006; Knowles et al., 2005; Vygotsky, 1978). Learning is social and occurs as adults interact with one another as they share their experiences, create new knowledge as they explore information that is new to them and associate it with that which is already known (Knowles et al., 2005; Vygotsky, 1978).

The next section moves from theory to prescriptive and empirical research on reform mathematics education, coaching, change and moving educational research to practice.

Prescriptive and Empirical Literature

This study was informed by prescriptive and empirical literature on reform mathematics education, coaching, the change process and moving educational research to classroom practice. Teaching mathematics in a way that reflected the reform mathematics

standards required professional development because the approach was so different from traditional mathematics instruction. Coaching is a way of providing continuous professional development that supports the teachers in their effort to teach differently. The literature on the change process, which spoke to the affective domain of the coaching process, shed light on aspects of moving a teacher from her current practice to one that reflected reform mathematics. Finally, the literature on the challenges of incorporating what the research says about teaching, to implementation in the classroom, is reviewed.

Reform Mathematics Education

Mathematics education has changed from the launching of Sputnik in 1957 to the present. There was a demand for change in teaching mathematics and the National Council of the Teachers of Mathematics (1980) outlined the changes they thought would meet the needs of the information age society; students would construct their understanding conceptually rather than acquiring knowledge through memorization. Reform mathematics programs were designed and evaluated for effectiveness. The following section describes the movement from traditional to reform mathematics education.

History of changes in mathematics education. Mathematics instruction in the United States has been criticized since the launching of Sputnik in 1957 sent shock waves throughout the United States as the country feared that our educational system was falling behind other nations, specifically in math and science (Marshall, Sears, Allen, Roberts, & Schubert, 2007). In the 1960s and 1970s, experts in mathematics (including college and university mathematicians, high school math teachers and supervisors) proposed curriculum with an increased emphasis on understanding mathematics including topics such as set theory and number bases other than base ten (Klein, 2003); this became known as the New Math

movement. Klein went on to explain that, due to controversy concerning the content and the challenges teachers faced as they attempted to teach the New Math, the movement was essentially dead by the early 1970s. The response was a back-to-basics push that advocated a more instrumentalist approach in which students learned and practiced algorithms and then were given tasks to apply what they learned. A characteristic from the New Math movement, an emphasis on the process whereby students explored and made sense of the mathematics, found followers in the curriculum developers in the 1980s.

Development of standards for reform mathematics. In 1980, a professional organization of mathematics teachers, NCTM published "An Agenda for Action: Recommendations for School Mathematics of the 1980s" (National Council of the Teachers of Mathematics, 1980), calling for extensive changes in mathematics education in the United States. In 1987-88, Romberg coordinated the development of the NCTM standards that were published in 1989 (Klein, 2003). Romberg (1992), when describing the scholarly basis for mathematics reform, focused on student performance and the needs of business and industry. He cited the criticism of the educational system in the United States in "A Nation at Risk" (National Commission on Excellence in Education, 1983) in which levels of education obtained by high school graduates were characterized as not preparing them for college or the work world and that, as a nation, our students were performing at lower levels than other industrialized nations. Romberg also cited the government publication, "Educating Americans for the Twenty-first Century: A Plan of Action for Improving the Mathematics, Science and Technology Education for all American Elementary and Secondary Students so that their Achievement Is the Best in the World by 1995" (National Science Board Commission on Precollege Education in Mathematics, 1983) in supporting the assertion that

there was a need for a better way of teaching mathematics. The National Science Board

Commission on Precollege Education in Mathematics (1983) developed their plan of action

primarily in response to "A Nation at Risk" (National Commission on Excellence in

Education, 1983) and NCTM's "An Agenda for Action: Recommendations for school

mathematics of the 1980s" (National Council of the Teachers of Mathematics, 1980) as a

way to prepare students for college or work in the information age. The plan called for

"fundamental changes in both what is learned and how it is taught" (National Science Board

Commission on Precollege Education in Mathematics, 1983, p. 3).

From industrial model to the information age. Romberg (1992) described typical

routines in mathematics classrooms as beginning with teacher explanations followed by

students practicing the procedures taught by the teacher. Routines were learned and then

applied to a given situation. A new approach in which students created new knowledge as

they explored multiple ways to solve tasks that exist in the real world was needed; this

approach would prepare students for college and the work world and enable students in the

United States to better compete with those in other industrialized nations. Schools were still

operating as a training ground for industry; preparing students for the information age called

for a very different approach. Learning theories informed mathematics educators as they

developed curricular and pedagogical documents to address the new direction of mathematics

education.

Constructing mathematics knowledge conceptually. Constructivists (Carr &

Hettinger, 2003; Cobb, Yackel &Wood, 1993) and sociocultural theorists (Vygotsky, 1978,

1986) claimed that learning occurs as the learner builds on their current level of

understanding. Sociocultural theorists described how students learn (Bakhtin, 1981;

Vygotsky, 1978; Walkerdine, 1988) using discourse to construct mathematical knowledge. The National Council of the Teachers of Mathematics (1989, 2000) determined that, to change mathematics education, emphasis on the process by which concepts were explored and ultimately understood, and the role of the teacher would need to change.

Explicit attention to understanding mathematics *conceptually* was identified as being an essential component of learning with understanding (Hiebert & Grouws, 2007). In reviewing research studies on the effects of classroom mathematics teaching on students, Hiebert and Grouws found a common characteristic in multiple teaching approaches— specific activities and discussions that explored the mathematics underlying procedures used to solve problems. Students did not just apply an algorithm, they explored why the algorithm worked and the mathematical components and numerical relationships that made up the algorithm. Alternate ways of solving problems were explored; student-invented approaches were encouraged. While different methodologies were used, teacher-student and student-student discourse was evident. Some of the techniques were more controlled by the teacher, but conceptual understanding was the target as opposed to a target of mechanical proficiency achieved through teacher explanation followed by repetitive practice.

Discourse. Sociocultural theory links communication and cultural practices with learning outcomes (Forman, 2003; Forman & Ansell, 2002; Moschkovich, 2007b; Sfard, 2002). In the mathematics classroom, this means that learning occurs through communicating mathematically in a social setting. Sfard, et al. (2002) define learning mathematics as " . . . becoming fluent in a discourse that would be recognized as mathematical by expert interlocutors" (p. 5). This viewpoint moves educators from viewing learning as acquiring knowledge from a more knowledgeable other and subsequently altering

a cognitive schema to negotiating an understanding through interaction with others through discourse effectuating a change in the ways they communicate with others (Forman, 2003; Newman, Griffin, & Cole, 1989; van Oers, 2002). Analysis of learning then resides in the dialogue itself (Gee & Green, 1998; Sfard et al., 2002; Vygotsky, 1978).

The responsibility of schools, then, is to design settings that bring students into the culture of the mathematics community and bring hidden assumptions to light as a means of determining the course of discursive practice (Bakhtin, 1981; van Oers, 2002). The challenge of moving classroom practice from a traditional to a constructivist approach involves a paradigm change and requires a renegotiation of norms. Research demonstrates that roles and responsibilities of students and teachers would change resulting in the process of learning mathematics becoming more reflexive (Cobb et al., 1996). To make the practice more reflexive, students and teachers would engage in talking about ways of talking about mathematics (Lampert & Cobb, 2003). It would be essential that the group develop a shared understanding of individual and group responsibilities, and of what it means to formulate and defend a proposed method or solution mathematically, to understand each others' explanations and to collaborate in their efforts to learn mathematics (Cazden, 2001; Lave & Wenger, 1991). Students and teachers frequently did not intuitively know how to participate in this new environment and classrooms often floundered when trying to use the discourse model. In their research, Forman and Ansell (2001) described two voices that emerged when students were explaining their solutions to the group—explanations of invented strategies and talk about standard algorithms. This represented the challenge of moving away from invoking the use of algorithms rather than exploring and understanding the mathematics.

Herbel-Eisenmann (2009a) cited a lack of clear direction from NCTM concerning how to accomplish the goal of learning with understanding. In subsequent research on classroom discourse, she showed that involving teachers in action research, providing them with professional development on classroom discourse enabled the teachers to identify and take action on aspects of their practice to increase classroom discourse.

Researchers have documented student interactions in which their mathematical talk did not contribute to solving problems and students struggled, often without success, to reveal their own thinking to others and to make their logic transparent (Kieran, 2002; Sfard, 2002). In other instances, an asymmetrical mathematical ability between students resulted in less knowledgeable students deferring to those who were more knowledgeable, without them either challenging their methods or asking for clarification (Lampert & Cobb, 2003). Students' ability to collaborate in solving mathematical tasks cannot be taken for granted (Sfard, 2002). To enable students to effectively use discourse as a means of becoming a participant in the mathematical community, they need to learn how to use practices they already know—arguing, defining, speculating, and defending—as they function in a mathematical realm (Forman, 2003; Lampert, 1998; O'Conner, 1998). As the teacher's and students' roles change, providing guidance for the change resides with the teacher.

Reform mathematics programs. In a longitudinal study, teachers learned to use Cognitively Guided Instruction (CGI) (Fennema et al., 1996) an approach based on models of students' mathematical thinking. When teachers based their classroom activities on the CGI model, students improved in the areas of concepts and problem solving. In another study, using a reform mathematics curriculum, the Connected Mathematics Project (CMP), Cain (2002) found that students performed significantly better than students using a non-

CMP curriculum and that both teachers and students believed that CMP was helping students to become better problem solvers. Professional development for teachers was needed to help them use curricular materials that aligned with reform mathematics; coaching as a continuous professional development model evolved as a way to address this need.

Coaching

Coaching is a professional development method used in education as a means to improve teacher practice and improve student learning (Poglinco & Bach, 2004). In this section, the research on coaching is reviewed as it applies specifically to student achievement, teacher practice and teacher thinking.

Because the mathematics literature located did not explicitly focus on coaching and decision-making, the literature on coaching in general is reviewed in this section. The lack of research tied specifically to a subject matter was noted in Hodgen and Marshall (2005). When findings of the research referred specifically to mathematics, that information is included. Otherwise, the research did not differentiate the effects on coaching in different subject matter areas.

Student achievement. This section explores the research on coaching as a professional development technique, one that has had mixed results echoing the results of professional development on student achievement in general. The literature described coaching as an effective method in professional development; the literature then claimed that professional development has improved student achievement (Borko, 2004; Joyce & Showers, 2002; Neufeld & Roper, 2003). Joyce and Showers (2002) claimed that peer coaching and training have become inseparable and that, when asked if staff development affected student learning, they responded as follows:

The answer is that not all of what is called staff development will directly improve

student achievement. In fact, most current offerings probably will not generate the

amount of change that is necessary to affect student achievement to an appreciable

extent. However, staff development can be designed that will affect student learning,

and not a little—large changes can be made. (p. 35)

While Joyce and Showers expressed optimism that there was a connection between coaching

and improved student achievement, there were few examples of literature describing research

that made that connection. The persistent difficulty lies with the many possible factors that

affect student learning, from student demographics to characteristics of the materials,

teachers, school site, district and policies affecting the classrooms (May & Supovitz, 2006).

Researchers who found a connection included Ross (1992), Ross and Bruce (2007), Rowan

and Miller (2007), May and Supovitz (2006).

Ross (1992) conducted research with 18 social studies teachers who were coached by

six peers as they learned to use new curricular materials. He claimed that, when teachers had

more contact with coaches, students performed at higher levels based on multiple-choice

tests given in September and May. In his research, coaches met with the teachers to discuss

the new program, the accompanying materials, and their classroom experiences. They then

explored ways to better implement the program. Coaches did not conduct observations of

peers.

Additionally, Ross's (1992) study explored the relationship between coaching and

teacher efficacy, and student achievement and teacher efficacy. Teacher efficacy is the

extent to which the teachers believe that they have an influence on what students learn. The

students in the classrooms with teachers who had a stronger belief in teacher efficacy

achieved at higher levels than those in classrooms with teachers who had weaker beliefs in teacher efficacy. However, there was no relationship found between the coaching experience and levels of teacher efficacy. Other studies explored teacher self-assessment.

Ross and Bruce (2007) paired teachers of equal experience and competence in a peer coaching setting where they observed each other in the classroom, gave feedback, devised strategies to improve practice and set teaching goals. Teachers participated in a self-assessment survey, observations and interviews. The results found self-assessment used with peer coaching and outside change agents to be a powerful technique for improving student achievement. The case study was qualitative and used teacher perceptions of changes in student performance including classroom utterances, classroom assignments, homework, and formal assessments to determine the effect on student achievement. Another study reporting on the professional development with coaching model was a study of the Success for All and America's Choice schools (May & Supovitz, 2006; Rowan & Miller, 2007).

Success for All and America's Choice. Rowan and Miller (2007) reported on a study whose goal was to better understand Comprehensive School Reform efforts. The three formats under scrutiny were Accelerate Schools Project, America's Choice, and Success for All. Accelerated Schools Project used cultural controls and will not be reported on here. America's Choice used peer coaching along with outside professional developers whose goal was to improve instruction and ultimately student achievement. America's Choice first implemented their writing program followed by their reading and mathematics program (mathematics results were not reported in this study). They reported significant improvements in reading in the later grades—third through fifth. The Success for All program, a highly scripted format, showed significant gains in early grades. Another study

on America's Choice reading and mathematics programs documented student academic gains (May & Supovitz, 2006).

May and Supovitz (2006) conducted an 11-year study of the impact of America's Choice on student achievement. Students took achievement tests yearly and data from five years before and six years after the implementation of America's Choice were amassed. The data collected were compared to other schools in Rochester, New York. Demographic data was collected, thus enabling researchers to account for variance in student characteristics including differences in their backgrounds. The longitudinal data noted that significant gains were made in the later grades—three through eight—and proved to be cumulative in subsequent years. While the America's Choice program had a very strong peer-coaching component, there were multiple factors including curricular materials that may have accounted for the gains, again exemplifying the difficulty in determining the effects of professional development models on student achievement. The following section explores the effect of professional development on teacher practice.

Teacher practice. It is important to remember that the ultimate purpose of staff development in schools is to improve student learning (Joyce & Showers, 2002). When assessing the effects of the influences of schools, administration, school districts and materials, the literature supports the claim that teachers have the greatest influence on students' academic outcomes (Joyce & Showers, 2002; National Commission on Teaching for America's Future, 1996; Neufeld & Roper, 2003). While it has been challenging to connect particular models of professional development to student achievement, researchers have been able to connect improved achievement with changes in teacher behavior (Bowman & McCormick, 2000; Kohler, Crilley, Shearer, & Good, 1997; Zwart, Wubbels, Bergen, &

Bolhuis, 2009). Neufeld's and Roper's (2003) research showed that coaching increased teacher instructional capacity (experience and knowledge), a prerequisite for increasing student learning. The following section describes the research as it relates to the relationship of coaching to changes in classroom practice, the role of trust in the coaching relationships and the effects of administrative support with respect to coaching on changing teaching practices.

    Changes in classroom practice. When added to other types of training, coaching has increased the likelihood that newly acquired models and pedagogical changes will transfer to the classroom (Joyce & Showers, 2002; Rudd, Lambert, Satterwhite, & Smith, 2009) In their research, Joyce and Showers (2002) found that coaching had a dramatic impact on transfer of training, an effect size of 1.42, when it was added to theory, demonstration and practice. Rudd et al. (2009) conducted a research study where preschool teachers participated in a group professional development session designed to increase their use of the language of mathematics when interacting with students during math lessons. The researchers found a statistically significant increase in instances of preschool teachers using mathematically mediated language after a two-week coaching component followed the workshop when compared to a baseline frequency of practice immediately following the workshop with no coaching component.

    In a study designed to change teaching practices, researchers analyzed three phases of the change process in an elementary school setting with four teachers, two of whom focused on mathematics instruction and two on reading instruction (Kohler et al., 1997). First, participants were given an overview of the innovation followed by an implementation period where teachers worked on their own. The second phase included a regimen of peer coaching

where an experienced teacher worked with four teachers as they continued their participation in the change process. In the third phase, teachers continued the implementation independently. In the first phase, there was little change in classroom practice; significant progress was made in the second phase and in the third phase, teachers were found to have sustained program practices developed in the second phase. While this study does not relate the teacher changes to student outcomes, it does document the relationship between coaching and change in teacher practice.

Zwart et al. (2009) conducted research in a secondary school setting where 14 teacher dyads pursued the goal of moving students from their current state of dependence on the teacher to one where they would learn more independently and be more self-regulated. Teachers planned together, observed one another, and critically discussed their observations, thinking, and beliefs concerning their practice and student behavior. Students, in a survey, were asked questions concerning changes in teacher behavior. The results indicated that, when peer coaching was implemented, students perceived a greater change in teacher behavior than prior to the peer-coaching sessions. Results concerning teacher learning demonstrated that teachers learned when they were intrinsically motivated to become better teachers, when they were pressured to try new methods, and when they were able to discuss their work in a safe, constructive, trustworthy reciprocal coaching situation. Similarly, student teachers who were assigned to peer-coaching dyads accomplished greater expertise in targeted areas than a control group (Bowman & McCormick, 2000). Part of the peer-coaching approach that was found to be particularly important was having coaches in the classroom observing and modeling (Poglinco & Bach, 2004). Additionally, Poglinco and Bach found that joint lesson planning, co-teaching, giving feedback on classroom practice,

and one-on-one conversations were essential to an effective coaching relationship. Group coaching proved to be less influential. Another important characteristic of coaching is the establishment of a relationship of trust in the coaching environment, as described in the following studies.

     Trust in coaching relationships. In the Appalachian Mathematics and Science Partnership (Murray, Ma, & Mazur, 2009), multiple school sites participated in a program to improve instruction and student learning in mathematics and science. New materials were introduced and implementation workshops followed. A coaching component was part of the professional development that included a coach who worked with teacher-coaches—dyads who functioned as reciprocal coaches. The dyads were made up of teachers from different schools and each coaching dyad met only four times to discuss the two observations done for each peer coach. The analyses of the conversations between the teachers revealed they were more descriptive in nature, simply describing the classroom and teacher actions rather than encompassing in-depth lesson analysis or reflection. The authors speculated that the teachers did not know each other well enough to have developed a trusting relationship where criticism would be seen as constructive.

     In another three-year study of an in-school coaching model (Craig, 2009), the school site coach was seen as being ineffective because she was perceived as more of a representative of the administration, and therefore in a position of evaluator rather than professional developer. Halai (1998) in her study using a peer coaching model, coached mid-career mathematics teachers as part of her academic research program. She found that when her role was perceived as being one of a problem solver or evaluator, the coaching process was less effective than when she was seen as someone whose role it was to help them

accomplish their personal and professional goals. Poglinco and Bach (2004) in their study of characteristics of effective coaching, found that, to be effective, the coach's role and authority needed to be clearly established to ensure program effectiveness. Another aspect of the educational environment affecting professional development discussed in the literature was support from school and district administration.

Administrative support. In the various schools who participated in Zwart et al.'s (2009) study, teachers who perceived less support from administration reported that they learned more from reciprocal coaching than did the teachers who perceived that they were offered more administrative support. Leonard and Leonard (1999) in their study on the effects of site principals and assistant principals on the change process, also found that teachers in two of three participating schools thought that informal efforts to change were stronger than more formal efforts, and the third school thought the effects of both were about equal. Other authors have emphasized school and district support as essential in changing teacher practice (Fullan & Miles, 1992; Poglinco & Bach, 2004), especially in providing resources needed to support successful implementation of the peer-coaching professional development. Time is a necessary resource, and it is difficult to create schedules that enable coaches to meet with the teachers or each other (Bruce & Ross, 2008; Guskey, 2003; Zwart et al., 2009). Teacher thinking and reflection is another important aspect of teacher change and time is needed to ensure that teachers have a space in their day to think about their practice.

Teacher thinking. Zwart et al. (2009) referred to teacher learning as a change in cognition and/or behavior. How teachers thought about and reflected on their practice was woven into many of the studies (Bruce & Ross, 2008; National Commission on Teaching for

America's Future, 1996; Zwart, Wubbels, Bolhuis, & Bergen, 2008) in which there was a coaching component in the professional development. Because the coaching model involves two or more people interacting, this process is, by definition, social in nature. A more knowledgeable other scaffolds the learning, moving the novice (with respect to the knowledge to be gained) forward in her practice (Garmston, 1987; Sowder, 2007; Vygotsky, 1978). Teacher self-reflection occurred more frequently and explicitly as a result of teacher interaction with in-school coaches (Bruce & Ross, 2008). Teacher self-assessment—thinking about and analyzing one's practice—was characterized as one of several activities important in the peer-coaching process (Ross & Bruce, 2007; Zwart et al., 2009) as teachers received focused input on teaching strategies.

Without an in-depth exploration of classroom behaviors, a coaching model can prove to be ineffective. Lack of analysis and reflection on lessons characterized peer-coaching interactions in which little change in teacher practice occurred (Murray et al., 2009). Peer coaches described what they had observed and did not delve more deeply into decisions made during the teaching process, effects of how lessons were conducted or exploration of alternative approaches. Other models of professional development, including those whose format is delivery of information only, did not include a component whereby teachers discussed or reflected on their practice (Ball & Bass, 2003; National Commission on Teaching for America's Future, 1996; Schmoker, 2006).

Change

Evans (1996) in *The Human Side of School Change*, brought the affective domain of professional development to the forefront. Asking teachers to change their practice, even beginning teachers, implies that their current enactment of curriculum, instruction, and

classroom management is not good enough. Their feelings of being valued could be compromised and their confidence could be deflated, especially in those teachers who had been deemed exemplary in the past. Beginning teachers might feel that they could never become competent.   Researchers, including Reeves (2010) and Fullan and Miles (1992) claimed that change at any time is not popular, and gaining teacher buy-in at the onset of a proposed change is either a myth or the change is not very substantive. Additionally, past experiences with school change initiatives have been negative or have not produced the promised outcomes.

Change initiatives often begin with an attempt to alter beliefs and attitudes of teachers. Fullan and Miles (1992) and Gusky (1986) have shown that change in instructional practice, followed by empirical results showing the effectiveness of the change, occur prior to the internalization of new beliefs and attitudes. This temporal effect—beginning professional development with training, enactment of new practice, evaluation of impact on student learning, then change in teacher beliefs and attitudes—is demonstrated by their research and yet many professional developers intuitively view change of beliefs and attitudes as a precursor to implementation (Sellar, 1987). Consequently, professional developers base their training models on that assumption. Changing the order of the foci of professional development can affect teacher buy-in.

Teachers have become cynical as they have seen a series of reform movements fail or be abandoned only to be replaced by yet another reform (Hall & Simeral, 2008). For example, reforms in mathematics have included New Math (Raimi, 2005), Back-to-Basics (Raimi, 2006), and Reform Math (National Council of the Teachers of Mathematics, 1989) each setting different priorities, proposing different approaches to learning mathematics and

employing different pedagogical techniques. While the New Math has been modified and

absorbed into current practice, there are advocates for traditional mathematics instruction

(Raimi, 2005) and advocates for instructional techniques that support reform mathematics

(National Council of the Teachers of Mathematics, 1989). As an educational community, we

search for answers and continue to struggle to find out what works in education, as well as

what teachers need in their practice to be effective, in order to ensure that their students learn

(National Commission on Teaching for America's Future, 1996).

Research to Practice

Most scholars who participate in research do so because they believe that, if done

well, the research can inform practice. Often times, the research is motivated by experts in

the educational community and their findings are presented in a format specific to the

research community (Cordingley, 2008). Huberman (2002) described researchers as

producing new knowledge or in some way modifying knowledge; that knowledge is

transferred to the public, and is then made use of in some way. Practitioners then

communicate their needs to researchers. He noted that communicating the new knowledge

and it then being translated into a comprehensible form and ultimately operationalized, was

multifaceted and challenging.

Four influences on the diffusion of innovations (or new knowledge) cited by Rogers

(1995) included (a) the innovation, (b) communication channels, (c) time, and (d) the social

system. Within each system, there are numerous factors that ultimately influence the

adoption of the innovation resulting, in the case of education, in the passage of many years

before full implementation is realized. From the time "A Nation at Risk" (National

Commission on Excellence in Education, 1983) was written to the present, thirty years have

elapsed. Schmoker (1996), wrote the following on the importance of research in education:

>Until we begin to routinely respect and respond to the best that is known about
>
>effective teaching and organizational improvement, we forfeit the benefits of the rich
>
>knowledge base that can inform our teamwork as we pursue substantive goals. Until
>
>we routinely consult this knowledge base, we limit every student and teacher in our
>
>system (p. 65).

Marzano (2003) attempted to address this problem by reviewing the research on what

works in schools and presenting the results in a format that educators could understand and

implement. He explained the research on school, teacher, and student level factors and then

delineated how the research could be implemented in an educational entity. Reform

mathematics required a change in thinking and in actual practice in the classroom.

Reform mathematics required a paradigm shift—current practice could not simply be

modified but required an entirely different approach (National Council of the Teachers of

Mathematics, 1989). Materials, teaching and testing were all elements of the changes needed

to accomplish the identified goals of mathematics education. In mathematics, the research

informed the standards written by the National Council of the Teachers of Mathematics

(1989) but practitioners wanted more information and materials that aligned with the

standards as a way to facilitate the implementation. In the 1990s, the National Science

Foundation (NSF) funded the commercial development of materials that embodied the

standards (Klein, 2003) as a means by which to support teachers as they attempted to teach to

the standards. Assessments including the NAEP were often content focused (Schoenfeld,

2006) and needed to be changed to align with the new standards (National Council of the Teachers of Mathematics, 2000; Pegg, 2003).

In the coaching environment, the coach is tasked with selecting and making the current research, as it applies to the teacher's practice, accessible to the teacher. As noted in this section, it is challenging to incorporate what researchers have learned into classroom practice. The research, the format in which it was presented, and the applicability to the topics identified in the coaching sessions all need to be considered when deciding what materials to use (Cordingley, 2008).

Summary

There were three main theories that informed this research study, constructivist theory, sociocultural theory, and adult learning theory. Constructivist theory is a learning theory that views learning as a process whereby knowledge is built on that which is already known. Sociocultural theory views learning as an interactive process in which discourse occurs between human beings as they develop knew knowledge or understanding as they negotiate meaning. Adult learning theory describes aspects of a learning environment to which adults respond. Prescriptive and empirical research also informed this research study as it related to reform mathematics education, coaching, change and moving research to practice.

Reform mathematics education was developed in response to criticism of pedagogical practices that resulted in students in the United States performing below other nations on mathematics assessments. Researchers and practitioners proposed standards and use of pedagogical techniques, including discourse, that advocated learning with understanding. Discourse was viewed as essential to understanding the math conceptually; students would

explore the mathematics and devise possible solutions to real world tasks through discourse with other students and the teacher. Curricular materials were developed and their effectiveness researched as a way to help teachers as they changed their ways of teaching mathematics. The research concluded that students understood the math conceptually when using reform mathematics materials and pedagogy.

Because reform mathematics instruction was so different from traditional mathematics, professional development was seen as a requirement to enable teachers to make changes in pedagogy. While a variety of professional development models were utilized, this research study explored coaching as a means to effectuate change. There were three main types of research reviewed (a) coaching and student achievement, (b) changes in teacher practice, and (c) changes in teacher thinking.

The research that focused on coaching and student achievement found that when a teacher was involved in a coaching setting, there was either no difference in student performance or improved student performance. Ways of measuring student performance varied from the teacher's perception to using a pre and post test from September to May, or by using assessment designed by the researchers. Because there are so many variables in an educational setting, connecting improved student performance with coaching is difficult to document.

Changing teacher practice through coaching was explored by targeting a specific practice and determining to what level teachers were implementing the intended change. In general, an increased level of change occurred when teachers worked with a coach as opposed to implementing changes independently. Trust and authority were found to be important attribute in the effectiveness of coaching. If trust had not developed between peer

coaches or if the authority of a coach had not been established, little change was observed. Administrative support was seen as both enhancing the impact of a coaching environment or not influencing the intended changes. In changing teacher thinking, including self-reflection and self-assessment, frequency increased as a result of working with a coach. Minimal change occurred when teachers did not reflect on their practice. The concept of change and responding to proposed changes impacts coaching.

The change process has been researched as it relates to educational change. Change can impact the relationship between teacher and coach because change may be threatening to a teacher. Some of the research suggests that teachers need to first try the new methods and that internalized beliefs change as a result of teachers seeing that the change helps their students. Moving research to practice is another challenge for a coach.

Research is often done with the research community in mind and the results are presented in a way that aligns with expectations of that community. It is challenging to make the results of the research operational in the classroom. The research can be written in a way that is understandable to the practitioners and distributed in ways that are accessible to the general public. The research showed that it is important that a specialist be involved in brokering and mediating the use of information described in the research.

This chapter included an overview of three theories that informed the work, constructivist theory, sociocultural theory and adult learning theory. Then the prescriptive and empirical research on reform mathematics, coaching, change and moving research to practice was reviewed. The next chapter will put forth a detailed explanation and description of the research methodology used for this research study.

CHAPTER 3

METHODOLOGY

This chapter explains the methods used in carrying out this research study beginning with the general perspective, then the research perspective. The research context and a description of the participants are followed by a description of the instruments used in data collection. The procedures used are detailed followed by the methods used in the analysis of the data.

General Perspective

Background of Study

Research on the effects of coaching on teacher practice was the motivation for the design of this research study on coaching and student/teacher discourse. Zwart, et al. (2009) referred to teacher learning as a change in cognition and/or behavior. Teacher thinking and reflection on their practice has been viewed as an integral part of making changes in practice (Bruce & Ross, 2008; National Commission on Teaching for America's Future, 1996; Zwart et al., 2008) in a coaching setting. Through discourse, a more knowledgeable other supports the learning, moving the novice forward in her practice (Garmston, 1987; Sowder, 2007; Vygotsky, 1978). Teacher self-reflection occurred more frequently and explicitly as a result of teacher interaction with in-school coaches (Bruce & Ross, 2008) and teacher self-assessment was characterized as an important aspect of the peer-coaching process (Ross & Bruce, 2007; Zwart et al., 2008).

The model that aligned most closely with the intent of this research was the content-focused coaching approach. West and Staub (2003) defined content-focused coaching as "a professional development model designed to promote student learning and achievement by

having a coach and a teacher work jointly in specific settings, guided by conceptual tools" (p. 1-2).

The teacher and the coach participated in conversations where the goal was to design classroom events that furthered student understanding of mathematics concepts. The tools used to develop instructional techniques that furthered conceptual development included teaching and learning theories, standards, curriculum, educational philosophy, teaching methods and learner knowledge. Together, coach and teacher discussed the role of discourse in the mathematics classroom and reflected on her practice. Over the course of the research project, the coach provided readings that informed and helped the teacher to position herself on a continuum between traditional practice and effective implementation of reform mathematics teaching (National Council of the Teachers of Mathematics, 2000) and helped her to move from her past practice to desired practice. Furthermore, the teacher and coach discussed ways to advance the mathematical learning of English language learners (Tellez, Moschkovich, & Civil, 2011) as it applied to mathematical vocabulary and student explanations.

Research Question

As an extension of the empirical research described above, I designed and conducted a study to answer the research question, "How does the coach make decisions when coaching a middle school mathematics teacher on classroom discourse?" The purpose of the study was to shed light on the ways a coach made decisions that supported the teacher as she developed mathematical discourse in her classroom. The instructional approach was based on reform mathematics. The following section describes the research perspective of this study.

Research Perspective

Qualitative Research

The research method chosen for this study was qualitative and based on the belief that "reality is socially constructed, complex and ever changing" (Glesne, 2006, p. 6). Qualitative research allows the researcher to explore ways people perceive and interact with the world. The methodological design used for this research was a design experiment where the researcher focused on ways the discourse of a mathematics teacher and her students evolved when the teacher participated in coaching sessions with the coach/researcher, as the students and teacher explored mathematical concepts together.

Design Experiment

Design experiment methodology, a method based on grounded theory, is a research method that is used for conducting research in a classroom setting. Design experiment methodology is similar to grounded theory but is described as a method by which "to work toward a theoretical model of learning and instruction rooted in a firm empirical base" (Brown, 1992, p. 143).

Brown (1992) conceived of design experiments as a way to innovate in a classroom as a means to develop learning theories that would inform educators, learning theories that would be useful because they were empirical studies of what actually occurred in a setting similar to those of many classrooms. As described by Cobb, Confrey, diSessa, Lehrer and Schauble (2003), "Design experiments are conducted to develop theories, not merely to empirically tune 'what works'. These theories are relatively humble in that they target domain-specific learning processes" (p. 9). While Brown and Collins (Cobb et al., 2003) were associated with the development of design experiment methodology, revisions have

been made and the methodology has evolved as researchers explored how learning occurs *in situ*. Classroom environments are very complex and vary from one educational setting to another; design experiments attempt to study phenomena within these diverse environments.

Crosscutting features of design experiments. Cobb et al. (2003) delineated five crosscutting features of design experiments. The first is that design experiments have the goal of developing a class of theories on the processes of and support for learning. The second feature is the highly interventionist nature of the research as new ideas are tested. The third is that, although theories are developed, they must also be questioned and critically examined for additional possible explanations for that which is theorized. Fourth, design experiments are iterative—conjectures are made, tested and revised repeatedly as the experiment unfolds. The fifth feature is the nature of the theory developed by the researchers—it is pragmatic and informs instructional design, it is not abstract and philosophical.

The design experiment methodology was used for this research project because the focus of the research was how decisions were made in the coaching process as a means to influence the nature of classroom discourse in mathematics between the teacher and the students. The complexities of the classroom required a methodology that responded to the circumstances that unfolded as the participants interacted with each other. The research was positioned in the professional development viewpoint delineated by Shulman (2004) in which the teacher is supported in ways that reflect the five principles that guide teacher learning, "activity, reflection, collaboration, passion, and community or culture" (p. 513) as she developed ways to influence the social context of the classroom including social norms, sociomathematical norms and classroom mathematical practices (Stephan & Cobb, 2003).

Classroom norms. Social norms describe accepted ways of interacting in the classroom as established by the teacher and the students. Sociomathematical norms refer to the agreed upon ways of communicating in the mathematical learning domain and can include such issues as what constitutes an acceptable explanation of the solution of a math problem. Classroom mathematical practices can be viewed as "mathematical interpretations that become normative" (Stephan & Cobb, 2003, p. 42) in the classroom community through communications among students and the teacher. These three aspects of classroom discourse provided the context for the coaching sessions.

Purpose of the Research

The purpose of the research was to uncover ways the coach made decisions based on current teacher practices, by exploring how the practices evolved over time as the teacher and coach/researcher made sense of classroom mathematical discourse as a means to support student learning of mathematics with understanding. Because design experiment methodology provided a means to develop theory based on what the data revealed, the data represented what occurred in the context in which the discourse took place. The discourse emerged organically thereby enabling the researcher to gain insight into the "learning ecology—a complex, interacting system involving multiple elements of different types and levels" (Cobb et al., 2003, p. 9) and how the discourse functioned to support learning and inform decisions made to move the teacher forward in her practice.

Discourse in classroom and coaching settings. The researcher focused on the teacher's utterances in the teacher-student discourse to gain an in-depth understanding of how the teacher elicited and responded to the students' internal perceptions by observing the external representations (Hiebert & Carpenter, 1992) and hearing the teacher's questions and

comments in response to the students' explanations of their logic and processes as they sought to build connections and fully comprehend the mathematical concepts being explored. The data provided rich information on which to make coaching decisions that affected the discourse between students and teacher over time as approaches used in questioning and use of comments and prompts were analyzed and modified in an attempt to maximize the students' understanding of complex mathematical concepts as they responded to the teacher in creative and particularistic ways. The social construction of concepts and perceptions as related to teacher comments and questions as she interacted with the students was analyzed in the context of and relationship to what the students said and did as the teacher and student co-constructed the ways of understanding the mathematics. The coaching session discourse was analyzed for evidence of relationships of the teacher/student discourse as the coach and teacher co-constructed approaches of interacting with the students. The following section describes the context in which the research took place.

<div align="center">**Context and Access**</div>

The proposed research project was conducted at La Escuela (a pseudonym), a private, religious-based neighborhood school that was funded through donations. The school opened its doors in the school year 2007-2008 with one class of sixth graders and then expanded by adding a grade level per year now housing three grade levels, sixth, seventh and eighth. During the 2012-2013 school year, the enrollment was approximately 15 sixth graders, 16 seventh graders, and 11 eighth graders.

During the first year, the director and teachers were volunteers, the people who made repairs and fixed the buildings were volunteers and the after-school tutors were volunteers. One person, an assistant, was paid a nominal salary. When this research was conducted, there

were three paid teachers who chose to teach at this school despite receiving far less compensation than if they taught for the state's public schools.

The people who worked together to establish the school were the parents, students and members of the local ministries. The students who attended the school were from the neighborhood. The majority of the Latino/Hispanic students were from Mexico or their parents were from Mexico; the students spoke Spanish and English during the school day both in social settings and during academic activities.

The former director of the school is a member of my doctoral dissertation committee. The current director agreed to provide access to participants for the study. The school was chosen because they implemented a reform mathematics program using Connected Mathematics Program (CMP) (Lappan, Fey, Fitzgerald, Friel, & Phillips, 2009) materials and the educators at this site were willing to participate in research programs. They allowed me into the school setting to conduct the proposed study.

Participants

This study was a researcher participant study. I was the coach who worked with the teacher to explore her utterances as she interacted with the students over time. In my professional roles, I have had extensive experience working with teachers in professional development settings. I was a mathematics teacher, the principal of an elementary school, computer instructor at a post secondary institution and director of curriculum in a medium size, rural, low socio-economic status (SES) school district in a southwestern state. I have designed and delivered professional development workshops on assessment, curriculum and mathematics instruction. As a principal, I observed and evaluated over 100 teachers as they delivered instruction in the classroom. As a director of curriculum, I conducted mathematics

curriculum writing sessions, materials review and evaluation, and training sessions in the use of reform mathematics curriculum. As a research assistant in a National Science Foundation Grant, I collaborated with Dr. Richard Kitchen and Berenice Castellón in a study on mathematics learning of Latino/a students. These extensive and varied experiences qualified me to fulfill the role of coach in this study.

The teacher participant was chosen by convenience sampling (Morse, 2007)—that is selected on the basis of availability—from individuals who taught mathematics at the school and were willing to volunteer to take part in this study. The teacher volunteer was given information on the goals of the research, the methodology, time commitment, anticipated benefits, and possible risks. The following safeguards were communicated to the participant: she could discontinue her participation at any time and she could not be coerced by others to participate. This study was submitted to the Institutional Review Board (IRB) of the University of New Mexico. The IRB approved it and the research began shortly thereafter.

Instruments Used in Data Collection

This section includes descriptions of the instruments used in the data collection. Questionnaires were used to obtain demographic information and the teacher's beliefs on mathematics education. A classroom observation protocol served as a guide for the participants on what constituted a lesson that reflected reform mathematics standards. Audio recordings and transcriptions, a coach's journal, researcher notes and fieldnotes were means used to collect data in the field. Debriefing and post conference guides were employed by the researcher in those settings. Finally, a data matrix served as a tool as a way of helping the researcher make sense of the data.

Questionnaires

A questionnaire "Mathematics Teacher Questionnaire Main Survey" adapted from the

Third International Mathematics and Science Study (1999) was given to the teacher as a

means to gain knowledge concerning her background, education, experience, classroom

practice and beliefs about teaching mathematics (Appendix A). More specifically,

information concerning what it meant to be good at mathematics and by what means the

teacher deemed to be the most effective way to help students become good mathematicians

factored into the content of the coaching sessions. The teacher's attitudes toward how

students related to mathematics—their levels of confidence, enjoyment of mathematics,

mathematics aptitudes—informed her practice. The teacher's perception of her mathematical

knowledge and types of pedagogy and materials she employed provided baseline information

and a point at which to begin the coaching conversations.

At the end of the research, the teacher was given a post questionnaire that was similar

to the initial questionnaire, "Mathematics Teacher Questionnaire Main Survey" (Appendix

B) adapted from the Third International Mathematics and Science Study. Additional

questions concerning the teacher's thoughts and opinions on the research study were

included.

Classroom Observation Protocol

A classroom observation protocol that was adapted from the National Center for

Research in Mathematics (1992) and a scale addressing academic language support for ELLs

(Rubenstein-Avila, 2006) was used as a reference by the teacher and coach to guide the

observations of the classroom sessions (see Appendix C). The protocol included indicators

and criteria with which to rate aspects of the classroom including intellectual support, depth

of knowledge and student understanding, mathematics analysis, mathematics discourse and communication, student engagement and academic language support for ELLs. For the purposes of the research, the value of the instrument was to help the teacher and coach determine what constituted best practices at the beginning of the research; it described envisioned practice in observable terms.   It served as a tool to ensure that both teacher and coach had a common frame of reference as they discussed classroom observations.

Audio Recordings, Journal and Notes

The main corpus of data came from the audio recordings and associated transcriptions of the coaching sessions and observations of the classroom mathematics lessons. Additional data was obtained through field notes including classroom observations, school activities, and informal interactions with the school community. Other information was accessed through school bulletins, internet sites, curriculum materials. The coach/researcher kept a journal during the research period. The following table summarizes the data sources.

Table 1

Data Sources

Classroom Sessions	Coaching Sessions
Coach journal—relating to classroom work	Teacher questionnaire—Appendix A
Classroom observations—audio recordings and transcriptions	Audio recordings/transcriptions
Field notes—classroom and school environments	Coach journal—relating to coaching sessions
	Curriculum documents and materials
Other: school bulletins, internet sites, community attributes, school activities	

Classroom sessions. Classroom sessions were observed and notes were made by the coach; teacher comments were audio recorded and transcribed. This allowed the teacher and coach to review and analyze teacher actions and comments as they influenced students' actions and comments, and they then proposed possible interpretations of what occurred as the students addressed the mathematical tasks. During the data collection, the audio recordings were used as a means for the coach to revisit the teaching sessions, analyze the teacher's decisions as they related to classroom discourse and then used to inform coaching decisions. Transcripts were coded line by line as a way to analyze the data and find categories that fit with what the data revealed. (Data analysis is discussed in more detail later in this chapter.) The coding enabled the researcher to gain insight into the data on which to base the conjectures, and to test for possible explanations of what was occurring.

Coaching sessions. Coaching sessions were audio recorded. Audio recording was easily accomplished and, because there were only two speakers, the researcher could readily discern what the coach and teacher said respectively. Audio recordings of the coaching sessions provided data concerning what decisions were made, how decisions were made and how those decisions related to practice at the beginning of the research as compared to desired practice. The teacher had transcripts of the classroom observations and coaching sessions as a means to revisit the sessions. The classroom observations and coaching sessions provided data that was used to delineate topics, their dimensions and underlying meanings for subsequent coaching sessions. Additionally, the data implicated material for teacher study, and identified aspects of the teaching on which to analyze and reflect. Classroom observations were coded as a means of analyzing what was happening in the classroom (see Figure 1).
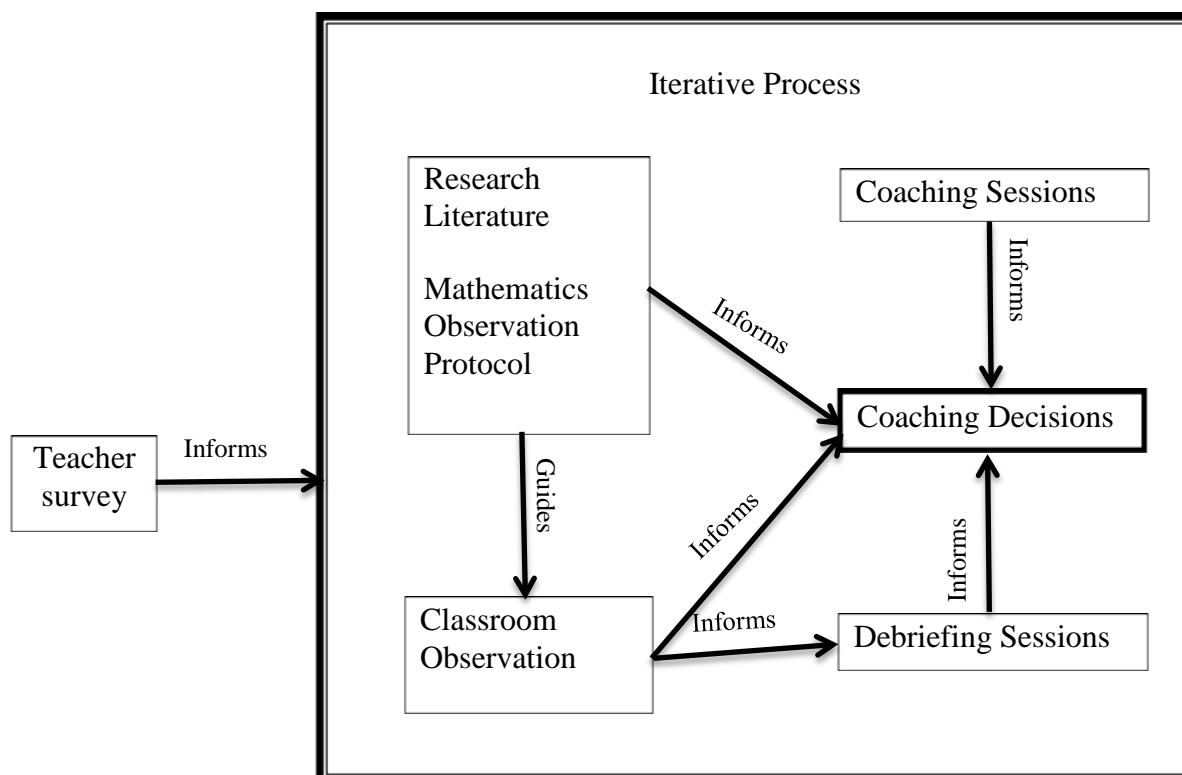
Figure 1. Graphic representation of the research process and relationship of key tools and events. The coaching decisions cell is emphasized reflecting the focus of the research.

Journal and notes. The coach recorded fieldnotes relating to the school and school setting, the mathematics classroom, and kept a journal reflecting on coaching sessions. Analytic memo writing and figures depicting relationships of what was observed aided the researcher as she attempted to make sense of what was happening in the coaching setting.

Debriefing and Post Conference Guides

Two instruments were used to guide the coach when debriefing the teacher after a classroom observation and the post conference that occurred during the first part of each coaching session. The "Debriefing Conference Question Guide" was adapted from Dantonio (2001), *Collegial Coaching: Inquiry into the Teaching Self* (Appendix D). The "Post

Conference Coaching Conversation Form" (Appendix E) was designed by the researcher and included questions on aspects of the lesson, discourse, and student learning with understanding. Based on that discussion in the coaching session, conjectures on what was occurring in the classroom and ways to improve practice were made and recorded on the form. Then the goals for the next lesson were discussed and a general lesson plan was developed and recorded on the Lesson Plan form (Appendix F). developed by the researcher using the literature on coaching (Dantonio, 2001; Knight, 2009; West & Staub, 2003). The next section describes the data matrix used to analyze the data.

Data Matrix

A researcher designed data matrix was used to organize the data (Appendix G). Gerunds were used to get a sense of what was happening and topics discussed in coaching sessions and were included in the matrix. There was constant comparison of the coding being done, to the coding of earlier data, and from this emerged conjectures explaining what was happening. Evidence including quotes from the data sources was included in the matrix.

<div align="center">

Procedures Used

</div>

Structure of the Research Project

The research was conducted during an eight-month period; the classroom sessions and coaching events took place at mutually convenient times for the teacher participant and the researcher, who was also the coach. During open coding, which started soon after data collection began, the researcher looked for similarities and differences in aspects of the phenomena being observed ultimately formulating categories based on conceptually similar codes. The overall structure of the research was as follows.

Table 2

Structure of the Research Project

Session	Activity
1	Coach discussed the research project with participant—Appendix H Coach obtained demographic information and information related to teaching mathematics—Appendix A—the form was given to the teacher prior to the meeting. Discussion was audio recorded. Next meeting date was set.
2	Initial Interview—Coach and participant discussed mathematics instruction, curriculum, approaches, beliefs, philosophy using Appendix A as a guide. Began process of identifying instructional topics on which to focus.
	The following steps were repeated throughout the research project.
3	Pre-conference--Planned logistics of classroom observation; day, time, lesson topic and learning goal, Appendix F. During the first pre-conference, teacher and coach discussed the lesson she had planned, which served as a baseline lesson. Lesson goals, strategies, and focus of the observation were identified. Subsequent pre-conferences reflected decisions made in the post-conferences.
4	Coach observed and took notes on the mathematics lessons—60 to 90 minutes and audio recorded teacher comments and questions.
5	Coach transcribed the observation audio recordings of the teacher's utterances and analyzed them using applicable sections of the Mathematics Classroom Observation Protocol (Appendix C) and the learning or teaching goals identified during the pre-conference. The coach coded the transcriptions, made notes and wrote memos on what was observed including general impressions and other salient issues.
6	Debriefing conference: As soon as possible after the lesson observation, using Appendix D as a guide, coach and teacher discussed the lesson. This session was designed to capture the immediate thoughts and feelings concerning the lesson, ideas that might have been forgotten over time. It was audio recorded, transcribed and coded, then used to inform the coaching sessions. The observation and the debriefing conference informed decisions made by the coach concerning information and support needed by the teacher.
7	Post Conference—Coaching Session Teacher and researcher met to discuss the observation, and analyzed what occurred in the lesson. They compared their observations to the intended learning and teaching goals, made conjectures as a means of making sense of the data and informing the next teaching episode (Appendix E). Debriefing sessions were discussed at this time. The coaching sessions informed decisions concerning teacher needs. Coaching sessions included the following (Stephan et al., 2003; West & Staub, 2003):

Session	Activity
	• Lesson goals. • Evidence of student learning with understanding. • Evidence of student misunderstandings, misconceptions. • Strategies used to make student thinking public. • Instructional techniques employed to foster learning with understanding • Conjectures—develop possible explanations concerning teacher practice and student/teacher discourse. • For next lesson, identification of classroom discourse goals and explication of teacher moves to achieve those goals. • Identification of resources to assist teacher in reaching identified goals.
	Design experiment research methodology is based on an iterative process. Sessions 3 through 7 were be repeated. Data was collected in the 4 cycles of data collection.
8	Post research session—A post research questionnaire was filled out by the teacher (Appendix B). This was compared to the questionnaire given at the beginning as a tool to document changes.
9	Member checking session. The analysis of the data is ongoing so member checking occurs continually. At the end of the research project, the researcher discussed the theory that emerged to determine if it aligned with the perception of the teacher.

Procedures

In this section, I will elaborate on the procedures that were implemented in the research. While a design experiment is one where the theory emerges from the data, the data must be systematically gathered and analyzed throughout the research project (Strauss & Corbin, 1998). The process began with building rapport (Hull, Balka, & Miles, 2009) and developing an in-depth understanding of the classroom teacher with whom the coach worked. Additionally, the coach spent time in the classroom in order to become a familiar entity in the classroom setting. Hull stressed the importance of being visible, respectful and professionally friendly in the classroom in which the research is conducted.

Session 1—Research overview and initial questionnaire. In Session 1, the teacher and coach discussed the overview of the research (Appendix H.) and what was expected of each as the project moved forward. The overview provided a document to which participants could refer as a means of viewing the overall processes and organization of the research and to ensure that both parties had a clear vision of the project. The questionnaire was given to the teacher as a means to gain knowledge concerning her background, education, experience, classroom practice and beliefs about teaching mathematics (Appendix A). More specifically, information concerning what it meant to be good at mathematics and by what means the teacher deemed to be the most effective way to help students become good mathematicians factored into the content of the coaching sessions. The teacher's attitudes toward how students related to mathematics—their levels of confidence, enjoyment of mathematics, mathematics aptitudes—informed her practice. The teacher's perception of her mathematical knowledge and types of pedagogy and materials she employed provided baseline information and a point at which to begin the coaching conversations. The questionnaire provided the basis for the interview in Session 1. The time and date for the next session was arranged.

Session 2—Discussion of beliefs and the mathematics classroom. In Session 2, the teacher and the coach continued the discussion on mathematics instruction including curriculum, instructional approaches, beliefs, and philosophy. The role of discourse in the mathematics classroom was discussed and a copy of the Mathematics Classroom Observation Protocol (Appendix C) was given to the teacher to provide a basis for exploration and discussion in the coaching sessions. This session provided time to discuss the characteristics of an ideal classroom as envisioned by the teacher, and to diagnose teacher needs (West & Staub, 2003).

Session 3—Pre-conference. The main focus of Session 3, the pre-conference (West & Staub, 2003), was to plan the classroom lesson. Lesson goals, instructional strategies, and the focus of the observation were identified (see Appendix F). The coach and teacher also discussed possible feelings of apprehension or concerns the teacher may have had. The curricular goals of the lesson, the way in which the lesson would be conducted, and the materials to be used dictated the focus of the lesson.

Session 4—Lesson observation. In Session 4, the coach observed the lesson and took notes on the general setting, materials, and any other actions germane to the lesson. An audio recording of the teacher's utterances during the lesson was made by using a lapel microphone that fed into a digital recorder.

Session 5—Lesson transcription and analysis. Session 5 was spent transcribing the lesson and analyzing what had occurred. At this point, the coding took place and as the research continued, the most recent coding was compared to earlier coding. These comparisons informed the conjectures.

Session 6—Debriefing. A debriefing of the lesson, Session 6, followed the observation of the classroom lesson as soon as was possible (Appendix E). The discussion of the overall impression of the lesson occurred immediately after to capture the teacher's and coach's thoughts and feelings before they were forgotten. These first impressions were compared to later thoughts as to what occurred during the lesson. The teacher was asked to reflect on the lesson, a way of developing habits of self-monitoring and self-reflection (Dantonio, 2001; West & Staub, 2003). The teacher considered the following: were the intended goals accomplished, were the strategies employed as intended and were they effective, and did the discourse promote sense-making of the mathematics? In this debriefing

session, the coach and the teacher participated in discourse as a means to make sense of what occurred in the lesson. The discussion was audio recorded. Transcripts of the observation of the lesson and the debriefing session were made and coded.

Session 7—Post conference and coaching session. The observation of the lesson combined with what was learned in the debriefing session was the focus of Session 7 (Appendix E) as the teacher and the coach analyzed the transcripts of each event together. The Mathematics Classroom Observation Protocol (see Appendix C) and the coded transcripts provided the basis for the coaching sessions. The teacher made known her reflections on what worked to advance student learning and develop productive classroom discourse. The teacher and coach discussed observations and coded transcriptions and formulated conjectures on what was happening in the classroom; decisions concerning teacher pedagogy for the next lesson observation were made. This session also provided information for coaching decisions concerning resources (book chapters, videos, other references) and instructional support (specific actions, questioning techniques, ELL teaching approaches). The session was audio recorded and transcribed. The coach wrote analytic memos and developed conjectures based on the findings. The goal of the research was to develop theory based on what emerged from the data and the conjectures focused the research on possible explanations.

In the coaching session, the coach and teacher also addressed anxiety and possible feelings of inadequacy or fear of being judged. Change implies that previous practice was less than successful which can erode confidence (Evans, 1996). By bringing up the possibility of these feelings, and assuring the teacher that the feelings are to be expected when participating in analysis and change of practice, the teacher was able to manage any

fears she may have had (West & Staub, 2003) as evidenced by her continued participation and changes in her practice.

The teacher and coach set curricular and instructional goals for the next lesson to be recorded. The coach and teacher each decided on one or two topics on which to focus to support incremental change to avoid becoming overwhelmed. Teacher instructional practices that supported productive classroom discourse were identified. Readings that supported the goals and shed light on aspects of classroom discourse were chosen and given to the teacher either during the coaching session or soon thereafter (see Appendix I). Prior to starting the research, three initial conjectures were made.

Initial Conjectures

Design experiments are based on a system of developing conjectures and then gathering data as a means of testing those conjectures. Conjectures made at the outset of the research were based on the research literature thus providing a starting point and anchoring this research in that which was done in the past. The ideology and pedagogy advocated in the reform mathematics approach was a significant departure from past practice (National Council of the Teachers of Mathematics, 1989) and has provided challenges for current practitioners (Herbel-Eisenmann, 2009a; Smith, 2000).

The first conjecture was based on Smith's (2000) research that focused on a teacher's dilemma concerning the importance of allowing students to struggle when problem solving versus the importance of ensuring student success. The teacher tended to break down a challenging task into units where students were highly likely to find the answers rather than deeply explore student thinking, instruction was large group with students answering questions with one word answers while the teacher lead the interactions with little detailed

input detailing student thinking. Coaching sessions to explore the teacher's thoughts on ensuring student success versus allowing students to struggle with engaging tasks may have emerged as a salient topic.

The second conjecture was based on Ball's and Bass's (2003) research in which the researchers found that students developed their understanding of mathematics through exploration rather than from teacher led explanations. Teachers have historically controlled the class including the discussions and the teaching of mathematical concepts. Instead, students learn as they employ exploratory, problem solving approaches that parallel the journeys taken by mathematicians as they have attempted to understand and continued to expand on mathematical ways to better understand the world (Sfard et al., 2002). The teacher's and the students' roles in the classroom were anticipated as being possible topics for coaching sessions.

The third conjecture focused on Khisty's (2002) and Moschkovich's (2007b) research on issues concerning the relationship of language and learning mathematics for Latina(o) students who are ELLs. The research suggested effective ways of incorporating academic language in a lesson such that the ELLs could better adopt the terminology making it an integral part of their explanations.

Data Analysis

In this section, I will describe the procedures I used in the coding, beginning with an overview followed by more detailed accounts of the process. The coding approach was derived largely from Strauss and Corbin (1995) with additional viewpoints and methods from Charmaz (1995) and Stephan et al. (2003). As stated earlier in this proposal, the research was based on a positivist viewpoint that assumed that reality can be discovered, is knowable

and understandable (Bryant & Charmaz, 2007). Because the research is inductive, data was gathered and reality emerged from that data.

In a design experiment, analysis is ongoing and occurs as a reflexive process (Stephan & Cobb, 2003). Open coding was the initial step whereby the researcher coded the data line by line as a means of understanding what was occurring (Strauss & Corbin, 1998).

Open coding assigns terms to the data. I did line-by-line coding as a way to make sense of the data, labeling and abstracting the data to discover categories (Appendix G). This procedure fragmented the data into discrete parts. There was constant comparison of the coding that was in process to the coding of earlier data and from this emerged conjectures explaining what was happening. Charmaz (1995) encouraged the use of gerunds in coding as a way of describing what was happening. In this research, terms for the teacher discourse that emerged included praising, reassuring, imbedding suggestions, clarifying, facilitating reflection, assessing progress, identifying topics, responding to inquiries or suggestions, and describing. As the data was coded, categories, the concepts that represented the phenomena in the data, emerged. The data told the story.

The next step was axial coding (Strauss & Corbin, 1998) in which the questions were "why or how come, where, when, how, and with what results" as a way of determining relationships among categories. This step contextualized the categories revealed in open coding. The structure (the why) and the process (the how) enabled the researcher to understand what was going on and were inextricably related. In this research, "When do students share their understanding of problems and with whom?" was a question that revealed what was going on in the classroom. Conditions under which phenomena occur can be categorized as causal, intervening or contextual. Causal conditions are sets of events or

happenings that influence phenomena while intervening conditions mitigate what happens. Contextual refers to the conditions under which an event or happening repeatedly occur. The axial coding enabled the development of mini-frameworks or conceptual diagrams showing the relationships among categories.

From this data analysis, generalizations were developed through the use of selective coding. It is at this point in the data analysis where categories were refined and integrated telling the story of the reality as revealed by the data. The integration process occurred between the analyst and the data (Strauss & Corbin, 1998), the analyst interpreted what was going on and recognized the relationships. Memos and diagrams helped the researcher locate the connections and make sense of the data as it coalesced into theory. Memos consisted of questions and thoughts concerning that which was observed, what it meant, how it might have related to other observations and conjectures. Analytic memos suggested possible explanations as to why the discourse was unfolding the way it was and how that informed the coach's decisions. Diagrams were used to audition possible relationships of observed phenomena. This process took the abstract categories and integrated them into generalizations, which then moved into theory development. While the researcher attempted to interpret the data accurately, there are inevitably aspects of the research study may be subject to questions concerning validity.

Validity

Maxwell (2005) defined validity as "the correctness or credibility of a description, conclusion, explanation, interpretation, or other sort of account" (p. 106). In the case of design experiment methodology, the data is abstracted to formulate a theory (Strauss & Corbin, 1998). To validate theory, the researcher returns to the data, performs a comparative

analysis, to determine if the theory is representative of most instances in the data. In the case of telling the story, the researcher can return to the participant and ask her if the story represents her experience.

That which may cause problems with the credibility of how the researcher interprets the data is a *threat*. To address the validity of a research study, the researcher needs to analyze various factors in the setting, including the role of the researcher to identify possible threats. Bias, convenience sampling of participants, reflexivity, and triangulation are discussed in this section.

Bias

One possible threat in qualitative research is researcher bias. As the researcher, I might have had specific expectations concerning the outcome of the work causing me to focus on certain aspects of the data and ignoring other aspects, or I could choose to report on only the data that coincides with my theoretical stance. Because I valued coaching as a way of impacting teacher behaviors, I had to guard against interpreting the data in a way that supported this bias.

In my research, I positioned the teacher as an educator who was interested in exploring discourse in teaching mathematics and the ways in which that discourse affected student explorations of mathematics. The coaching experience and teacher discourse may have been mediated by the teacher's underlying beliefs and experiences in ways that were not transparent. Outside events and influences may have contributed to observed changes in behavior and discourse. I needed to utilize the data and participant comments to explore alternate explanations for observed changes.

Privileging reform curriculum and focusing on socio-constructivist learning versus traditional, expository learning could have posed a threat to the credibility of my research. For example, if the teacher encouraged student use of an inventive solution, that communication may have been more prominent in the reporting and analysis of the data than discourse where an algorithm was used to solve a problem. The role of algorithms and memorizing math facts have been debated by mathematics educators; I lean toward the use of algorithms when students understand how they were developed and I support the memorizing of math facts as a way to increase efficiency in solving problems. These personal viewpoints may have been threats to the validity of the research.

Participants

Another threat to the validity of the research was the method by which the students and teacher were chosen. The selection was made based on access and convenience. There were two teachers at the school site who taught mathematics and the setting was a private, religious school. While the teacher had a bachelor's degree, she did not have a degree in education and did not have a teaching certificate in the state in which the research took place.

Interpretation of the data was also influenced by culture, gender, personal experiences, times in which we live, education, and personal preferences (Strauss & Corbin, 1998). It was important to make the familiar unfamiliar so the data could be seen in a new light. It was also helpful to question statements that include the word "never" or "always", or take meanings for granted when that assumption may have been culturally based.

Reflexivity

In interview situations, Maxwell (2005) described the phenomenon of reflexivity where the presence of the researcher was a "powerful and inescapable influence" (p. 109).

The participant in the research was influenced by who the researcher was, the process of the audio recording sessions, and concerns about how she was perceived. The extent to which researcher presence affected the data needed to be addressed but could only be approximated.

Creswell (2007) extended the idea of reflexivity to encompass the influence of the research on the researcher, participants and readers. All research is positioned within a stance and in a place and time that affects how it is perceived. The events that comprised the research were co-constructed between the researcher and participant. What was revealed and what remains private, how episodes were interpreted, what the participants felt about the research were all factors affecting the interpretation of the data. How did the culture, socio-economic status, gender and first language of the researcher influence what and how events are perceived? Finally, it is the reader who makes the ultimate interpretation of the work using their own lens. I needed to be self-reflective as I immersed myself in the data analysis, repeatedly exploring how characteristics of researcher and participants may have influenced the interpretation.

Triangulation

To determine the validity of the interpretation of the data, I triangulated the data. Schwandt (2001) defines triangulation as, ". . . a means of checking the integrity of the inferences one draws" (p. 257). In reviewing the audiotapes and observation notes, I looked for evidence that may have been discrepant from the general interpretation of the data. When this occurred, it necessitated revisiting the interpretation of the data to determine if the anomaly represented an outlier or if the data supported alternate explanations. Analytic memos provided additional insight into the meaning of the data. I was mindful of what I

choose to include. I also analyzed what was said through multiple lenses, and considered various possible interpretations.

My analytic coaching journal provided an additional source of data to check the interpretations resulting from the analysis of the coaching and classroom sessions. Thoughts that occurred outside of the coaching sessions shed light on how the data was viewed and a consensus between the teacher and me informed the interpretation. Member checking (Creswell, 2007), where the interpretations and analysis of the data were shared with the participant so she could judge the credibility and accuracy of the report, offered an additional method to check for validity. Researcher fieldnotes comprised an additional source of documentation on which to check validity. The coaching process was social and occurred in a larger context, a context that influenced how meaning was made beyond that which was recorded during the coaching sessions. After the data was coded, analyzed and triangulated, the theory emerged.

Summary

This chapter described a qualitative research study using design experiment methodology. The setting was a middle school where the lived experience of a mathematics teacher was explored as she participated in coaching sessions designed to support the development of mathematical discourse in the classroom. The instruments used in data collection included questionnaires, a classroom observation protocol, audio recordings of the teachers' utterances, debriefing and post conference question guides and a data matrix used to parse the data so it made sense. The research procedures included; (a) gaining access and identifying a teacher participant, (b) gathering demographic data and beliefs concerning mathematics education, (c) observing mathematics lessons, recording and taking notes, (d)

planning and participating in coaching sessions, (e) keeping a journal, ongoing data analysis, analytical memoing, and making decisions and plans for coaching sessions. Data was analyzed using open coding, axial coding and selective coding as a way of finding ways coaching decisions were made in a coaching environment to support the teacher in developing productive discourse in the mathematics classroom. The generalizations emerged as the data was analyzed until the culmination of the research project.

The next chapter focuses on the results of the study. The four themes that emerged, along with data supporting each theme, are described.

CHAPTER 4

RESULTS

The purpose of this study was to gain insight into how a coach made decisions when she participated in a coaching relationship with a middle school teacher as they explored classroom discourse in a middle school mathematics classroom. I was the coach/researcher in the study and Jill (a pseudonym) was the teacher. The data uncovered four major themes relating to how the coach made decisions: (a) beliefs, mathematical content knowledge and pedagogical content knowledge, (b) development of rapport and trust, (c) teacher responses and comments in the coaching sessions, and (d) research literature and teacher practice. In this section, I will provide the data that support the identified themes using information from the coach's journal, field notes, transcripts of the lesson observations, coaching sessions, and debriefing sessions. I included examples of discourse and comments that were representative of the themes.

Beliefs, Mathematical Content Knowledge and Pedagogical Content Knowledge

Beliefs, mathematical content knowledge and pedagogical content knowledge undergird a teacher's approach to teaching mathematics (Gates, 2006). Ideally, in a coaching setting in mathematics, the coach's, teacher's and school's approaches align, resulting in common goals to strive for in the mathematics classroom.   The materials used by the school, Connected Mathematics Project (CMP) (Lappan et al., 2009) reflected a commitment to incorporate a reform mathematics approach as described in the NCTM's Principles and Standards for School Mathematics (PSSM) (2000). I conjectured that information concerning the teacher's beliefs, mathematical knowledge, and pedagogical content knowledge about teaching mathematics was needed to establish the direction coaching would

take. Arriving at an agreed upon view of the goals of mathematics instruction was an important element of the coaching process.

There was also the possibility that Jill lacked mathematical content knowledge in areas addressed in eighth grade so content preparation was another topic that I considered. Finally, gaining information on Jill's preparation for and experience in teaching mathematics helped me decide the direction coaching would take.

Beliefs

At the beginning of the study, Jill filled out a questionnaire (Appendix A) and participated in an interview (9/5/13) in which her responses to the questionnaire were discussed to provide baseline information for the study. The questions were intended to gather information concerning her beliefs on the following topics: what it means to be good at mathematics, expectations of students, and classroom lessons. This provided me with a clear understanding of Jill's beliefs and instructional strategies on which her classroom lessons were based.

What it means to be good at mathematics. First, when responding to what was important in being good at mathematics in school on the questionnaire, Jill indicated that remembering formulas and procedures was not important, and thinking in a sequential and procedural manner was somewhat important. The areas she deemed to be very important were (a) understanding mathematical concepts, (b) principles and strategies, (c) being able to think creatively, (d) understanding how mathematics is used in the real world, and (d) being able to provide reasons to support their solutions. Jill indicated that understanding and applying the mathematics and verbalizing explanations of solutions were the most desired outcomes for the students.

Jill thought that students learned the material best when the mathematics was connected to real world applications. During the interview (9/5/13), I stated that, as students construct their understanding of mathematics, it is more meaningful when they connect the new knowledge to mathematical knowledge that is familiar. In response, Jill emphasized the importance of real world connections to the mathematics problems:

> I think it's like anything else, especially with teaching middle schoolers, that if I can't relate it back to their life, if I can't make it applicable to them, they see no point in learning it. So helping them see how mathematics is used in the real world allows them to give purpose to what they're learning, what I'm teaching helps them engage better and helps them see the need for it. (Interview, 9/5/13)

She thought that, while CMP (Lappan et al., 2009) materials provided examples of how the mathematics either represents something in the real world or can be used to solve real world problems, they may not be problems with which the eighth graders at La Escuela would identify. Jill gave an example of a real world project that was meaningful to the students—planning a school dance. Students had to determine costs and then determine what the profit would be if each attendee were charged a given amount, and how the profit would change when the price of the tickets changed. They also looked at the change in profit as the costs were varied and determined the minimum number of tickets they needed to sell to cover the basic expenses. Students generated equations and graphs to represent their findings. This real world example helped them connect problems they had been working on in the math book with a situation in which the mathematics would be useful to them. Jill and I agreed that discourse among students and connecting mathematics to the real world makes learning mathematics more meaningful and accessible to all students.

A challenging curriculum for all students is advocated by NCTM (National Council of the Teachers of Mathematics, 2000) and Common Core Standards-Mathematics (CCSS-M) (Common Core State Standards Initiative, 2010), because having the expectation that all students can learn math well is essential to high achievement levels. Jill commented that almost all students had the ability to learn mathematics as follows:

> As for students' natural talents, I think there's no denying that some kids are more naturally inclined to the mathematics. That being said, I think that most kids can learn it, I mean some kids pick it up fast and some kids have to work harder at it and that's perfectly fine. What I have seen is that those kids who are naturally faster with that in the beginning, eventually it gets hard and they don't persevere as well. They haven't had to, versus the kiddos who math has always been a struggle and they tend, in my experience, to actually go above and beyond their peers who never struggled because they had to persevere all the time. And so, yes, there is that difference between natural ability but it doesn't prevent them from learning and in some ways it can be detrimental to be really good in math at the beginning. (Interview, 9/5/13)

She viewed her students as being able to learn mathematics, but that some students appear to have a greater aptitude for it; they learn the concepts more quickly and can relate them to new knowledge with less support from the teacher and peers than other students.

Expectations of students. Second, the questions focused on what Jill asked of her students during classroom lessons. Depending on the type of lessons, students sometimes (a) represented and analyzed relationships using tables, charts or graphs; (b) worked on problems for which there was no immediately obvious method of solution; (c) wrote equations to represent relationships; (d) practiced computational skills; (e) used graphing

calculators to solve exercises or problems. She indicated that students were always expected to explain their reasoning and provide evidence in supporting their solutions through classroom discourse:

> They are required to provide reasoning and explanations, they are never allowed just
> to give an answer, they have to explain what happened and then usually when we get
> to the end of a main idea, we'll take all of the knowledge we've learned and then we
> will write out the basic steps and an algorithm. But it's only after they've spent time
> with it exploring and discovering it. So it is important that they get to that step. Just
> so they don't have to relearn it over and over again and have something to refer back
> to. We want to make sure that they are truly understanding what's going on and not
> just following rules. (Interview, 9/5/13)

Jill's responses aligned with reform mathematics (Common Core State Standards Initiative, 2010; National Council of the Teachers of Mathematics, 2000), in which there is the expectation that classroom members participate in discourse in the mathematics environment as they explain and provide evidence for their solutions. In the interview (9/5/13), she stated that the types of student responses to the mathematics lessons were specific to the subject matter and the educational goals of the individual lessons. For example, in the CMP materials (Lappan et al., 2009), an introductory lesson may have an easily discernible method to find a solution whereas an extension lesson would more likely have multiple solutions or solutions that required more time to uncover.

Classroom lessons. Third, Jill contextualized the aspects of classroom lessons that supported students as they made sense of the math. Jill responded to a question on what the

teacher and students would do as they explored the mathematics concepts in the classroom as follows:

> I launch it and then they work in groups and I walk around asking lots of leading questions. Not yes-no questions, open-ended questions that will challenge what they have or if they're stuck, we'll take them a step further. A lot of times, I'll just go around and ask them to explain to me what they have right now, they'll have to explain it to me and if something is not clear, I can ask them to clarify. And when we come back together, I do lead that discussion and summary. And then, when we walk through and are writing out an algorithm, we'll make sure that the final version is in a way that makes sense, and not teenager talk, which has a lot of *ifs* and *things* and *stuff*. And so basically I facilitate and, of course, if there are things that the kids are really struggling with, I will model for them. Mostly, I ask leading questions, seeing if they can get at it. (Interview, 9/5/13)

On answers in the questionnaire and subsequent interview, Jill responded that students would work individually with assistance from the teacher, work together as a class with the teacher teaching the whole class, and work in pairs or small groups without assistance from the teacher. Overall, Jill described the discourse as being aligned with her expectations; students discussed the meaning of the given task and each group member contributed ideas in finding the solution:

> They work alone for the first few minutes but that's only on one problem, and it is a shorter problem but beyond that they, for the most part, they are talking to each other or working together or having class discussion and so a lot of collaboration. They are

required, when we get to an answer to show their work. It is not just the answer and

so okay, how did we walk through the process. (Interview, 9/5/13)

Jill had established a routine of launching a lesson, having students work in small groups as

she walked around the room asking questions. At the end of the lesson, solutions to the tasks

were presented through interactions between the teacher and students.

As a way of getting a sense of how Jill's time was divided among educational tasks,

Jill indicated that she generally spent approximately 40% of the time in teacher-guided

student practice, 20% in student practice in groups independent of the teacher and 15 % on

re-teaching and clarification of content/procedures. The remainder of the time, 25%, was

spent on administrative tasks, homework, tests and quizzes, and teacher lectures. The next

area addressed was teacher mathematical knowledge.

Teacher Mathematical Knowledge

Another aspect of teaching addressed in the questionnaire was teacher mathematical

knowledge. In all areas of mathematics taught at a secondary level, Jill described herself as

being very well prepared with the exception of probability and statistics where she was

somewhat well prepared.

During the interview, Jill indicated that she loved math and that she attributed that to

having good math teachers as explained in the following quote:

With the knowledge piece, I think I was just lucky in that I had great math teachers

throughout my career up until college and it was just something I naturally enjoyed

until I hit calculus and then the love of math disappeared. Up until calculus, I just

loved math and I will never teach calculus. And, I was not a math major, I was a

science major. We use the math, of course, and I really enjoyed it and that was my

preparation and I do have a talent for math and I enjoy it and I enjoy kids so I get to

do both (teaching math and science). (Interview, 9/5/13)

As a science major, she often worked collaboratively with her peers conducting experiments

and solving problems. As a learning technique, Jill thought that a collaborative approach

worked in mathematics as well.

In the questionnaire, Jill's answers reflected beliefs that aligned with CCSS-M (2010)

and NCTM Principals and Standards for School Mathematics (2000) and she described

herself as being very knowledgeable in mathematics content. Jill's opinions on how she

thought mathematics should be taught provided a basis on which to implement classroom

discourse in a meaningful way.

Pedagogical Content Knowledge

Additional questions provided information about Jill's education level, post-

secondary fields of study, certification, and teaching experience. Jill had a bachelor's degree

in science and had taken several mathematics courses. She had not taken college courses in

mathematical pedagogy but the former director, a college professor who taught university

courses including those on mathematics pedagogy mentored Jill as she learned to teach

mathematics. He provided learning opportunities and resources for Jill when she came to

teach at La Escuela. Jill augmented her learning through readings on teaching mathematics.

She described her pedagogical content knowledge as follows:

Pedagogy wise I teach pretty intuitively. I have never sat through a class on

pedagogy. I do attend conferences where I pick up some stuff but most of what I've

learned has come from observing other teachers, working with the former director of

La Escuela, and reading. And then, just between my intuitiveness and what I do from

teaching many, what it feels like many years, five years now, I've been able to

modify. Okay, that didn't work very well but that seems to work. (Interview 9/5/13)

In summary, using the information garnered from the questionnaire (Appendix A) and

the follow-up interview (9/5/13), which was designed to expand on and clarify answers given

by the teacher in the questionnaire, I decided that the essential understandings of reform

based mathematics instruction were in place. I made the decision to use her beliefs as a

springboard to develop goals for her practice. The next step, as we entered the coaching

phase was to build rapport and trust.

From the time I recruited Jill to participate in this research study, I was building

rapport and trust with Jill. I continued to keep our relationship in the forefront of my

thinking because it had an important impact on the work of refining her practice.

Development of Rapport and Trust

Coaching literature (Hull et al., 2009; West & Staub, 2003) described the

development of rapport and trust as being a first step in the coaching process. When

analyzing transcripts and during coaching sessions, I made decisions concerning when to use

praise and empathy, provide reassurance, and acknowledge progress to help Jill feel safe and

confident that I had her best interests in mind as we explored her practice.

Praise and Empathy

I had visited La Escuela in prior years as a research assistant in another project and

had met Jill during that time. I also visited her classroom and provided help to individuals

and groups of students so I had become a familiar face at the school. Being a visitor is

different than formally observing a teacher for a research project and as I reflected on the

possible impact of coaching Jill, I noted in my journal:

The teacher is letting someone else into her space. That means the teacher is allowing scrutiny of what she does in her classroom—what she knows, how she relates to her students, what works well in a lesson and what does not work well. It is human nature to hope for praise for a job well done, and possibly feel defensive when questioned or when suggestions for change are made. There is a balance to be struck between making a difference in practice while ensuring Jill trusts me to have her feelings and best interests in mind. (Coaching Journal, 9/6/13)

In the first coaching session, I acknowledged and praised Jill's attributes and practices that were revealed in the initial questionnaire, interview and classroom observation in the following excerpt:

You are very knowledgeable mathematically so you have that in your pocket. You are also very well versed in the idea of reform mathematics and that process takes precedent over a product. So you have those ideas firmly established so we don't need to spend much time there. The idea is that, wherever you are in your teaching journey, we increase your menu of options. Because there are, certainly, as we have talked before, a variety of things that you do VERY well. (Coaching Transcript, 9/18/13)

This helped to build rapport by establishing the coaching experience as one based on Jill's past practice and building on her expertise. It was also meant to instill confidence so she could progress from a position of strength.

There were times when there was tension in the coaching sessions. Jill had multiple responsibilities and deadlines and my main interest was the coaching experience. Occasionally, Jill did not have the time to review transcripts or materials and I had to respect

the demands of her professional and personal life, be empathetic and remember that our focus was to move her practice forward. I reflected on this aspect of coaching:

> I realize that our relationship is in an adjustment period and that what happens in the coaching sessions reflects the other challenges Jill has in life as the on-site director. When a person has a lot of other things on their mind, reflecting on their practice may be seen as a luxury—instead, she is doing the best she can to fulfill expectations of the job. Jill, as the site director, works with the new teachers and has had to add to her instructional duties when teachers left until a new teacher was hired. (Coaching Journal, 10/14/13)

There were times when I needed to step back and give Jill more time to look over transcripts in the coaching sessions or more time to reflect on topics that were discussed in coaching sessions. I built trust by communicating that I wanted what was best for the students and for her practice and if she was unable to review or read materials, we would find time in our sessions to do it.

Reassurance

Reassurance was also a part of building rapport and trust. As Jill reflected on her practice, she had to evaluate what changes to make, one of which was intentionality. When discussing intentionality vis–à–vis the order in which students report their thinking in the reporting out session, Jill commented on the importance of being intentional and I responded, "I would agree, and that's what I said about refining your practice, because your practice is good. Those details make it better, and, like I say, more intentional because you do those things" (Coaching Transcript, 2/24/14). Comments reassuring Jill that her attempts at

making changes improved her practice were effective as a way of encouraging her to continue to refine her practice.

Acknowledging Progress

As the research continued, I acknowledged Jill's progress by describing the observations and celebrating successful implementation of her stated goals. The following quote is from a coaching session (10/14/13) when we were discussing student participation in the whole group setting:

Well, it sounds like you're really making some inroads into their being more public with their thinking and also valuing what others are saying and giving ownership to the students who have made the explanations. And that's really, really important, it certainly affects how students truly understand the concepts by listening, restating them and often times when they're restating them, I don't know if you run into this, they'll get partway through and they'll say to the other student, "Then what did you do?" (Coaching Transcript, 10/14/13)

And after the next lesson observation I described her progress in the following way, "Well, it sounds like you're having some success with moving these challenging eighth-graders to the front of the room" (Coaching Transcript, 11/6/13).

In another conversation Jill had related her enthusiasm when students asked each other for details and clarification as they explained a solution to a task. Jill stressed how the use of applicable vocabulary would have made their explanations clearer. I responded, "That's a great aha. I think it's one of those moments in teaching when you go, alright, you're finally getting what I've been trying to tell you" (Coaching Transcript, 12/12/13). By making

supportive comments, Jill received confirmation that I recognized her progress in her efforts to refine her practice.

In summary, building rapport early in the relationship facilitated a productive coaching relationship; trust may have taken longer to build and both aspects needed to be maintained over time. I actively made decisions concerning my comments by reading Jill's tone, body language, listening to and discussing professional and personal experiences as they related to our work.

Jill and I worked side-by side as we participated in discourse around teaching mathematics. We collaborated in uncovering topics—I asked questions of her that were based on what I observed in the classroom to elicit her views on what was happening in the classroom. We also discussed areas on which to focus to align her practice with her description of what was important as revealed in the initial questionnaire.

Teacher Responses and Comments

Jill and I discussed the transcript of the baseline lesson observation (Classroom Observation, 9/11/13). Based on an analysis of the lesson and subsequent debriefing, I made the following conjecture concerning student participation in the whole group setting; Jill had developed a routine for the lessons (Classroom Observation, 9/11/13) and at this stage of the coaching experience, asking questions of the teacher would be an effective way to increase her awareness of the practices she invoked to accomplish her pedagogical goals and identify target areas for the coaching sessions.

I made coaching decisions based on Jill's responses and comments in the coaching sessions. Two categories of interactions surfaced in the responses and comments made by Jill that informed those decisions, identification of topics of mathematics teaching that Jill

wanted to address, and negotiation of divergent views. In this section, I will elaborate on both of the aforementioned categories and give examples of each.

Teacher Identification of Topics

Jill identified three main topics that she wanted to address in the coaching sessions: voice intonation, student participation in the whole class sessions, and questioning techniques.

Voice intonation. When Jill and I discussed the book chapter, *Revoicing: The Good, the Bad and the Questions* (Krusi, 2009) Jill identified the first topic, voice intonation, which she wanted to address in her teaching. In my journal, I described the interchange as follows:

> Jill thought that most of what was in the article on revoicing was just a reminder of what she already did but one idea really resonated with her. The intonation of Jill's voice was letting students know if they were right or wrong and, to better explore student thinking, students needed to explain the process they were using to attempt to solve the task. When in a hurry, she said she was less likely to explore students' incorrect answers (Coach's Journal, 10/14/13).

I decided voice intonation was a good teaching practice to address initially because it was something easily addressed and the teacher could gauge her success in not letting students know if they were right or wrong by the students' responses. Jill reported on her progress as noted in my journal:

> She revisited how her voice intonation should not let students know if they were right—she had tried using a neutral voice intonation in her class today and said she did really well at not letting voice intonation get in the way (Coach's Journal, 10/14/13).

I asked Jill if making sure her voice intonation did not reveal whether the student had correctly solved a task made a difference in student willingness to explain their thinking to her and she responded as follows:

> And there are times when I question them and I'll have to verbally tell them it doesn't mean you're wrong. I just want you to explain. Tell me why you think or how did you get that. I have to assure them that when I am questioning them, it doesn't mean they're wrong. Of course I don't say that means you're right, either, but reminding them that I am asking you a question, it doesn't mean it's wrong so tell me what thought you had to get you to that conclusion (Coaching Transcript, 1/21/14).

In another coaching session (2/24/14), Jill and I were discussing the use of the Initiate-Respond-Evaluate (IRE) approach to teaching when the teacher lets students know immediately if they are right or wrong. We concluded that some students are more comfortable with that approach than one where students participated in discourse as they sought to discover the solution to a task. Jill said:

> They are somewhat uncomfortable if they give me a response and I don't go yes or no. And I've gotten better about my inflection, and it's getting harder for them to figure out from my body language if they are right or not. And that makes them so uncomfortable so the one comment that I made was that a lot of students prefer that (the IRE pattern). (Coaching Transcript, 2/24/14)

This comment highlighted the importance of eliciting explanations of student thinking by not revealing if the explanations were correct or not. Jill identified student participation in the reporting out sessions as another topic for the coaching sessions.

Student participation in whole class reporting out sessions. Student participation in the whole group reporting out sessions is an important part of classroom discourse (National Council of the Teachers of Mathematics, 2000). In reform mathematics, after discussing the task in small groups, students explain their thinking and solutions to the other class members and the teacher. Jill first described her goal for classroom discourse as follows:

> My goal for discourse is just that they'll just be more free with it. I feel that right now I have to push them a lot. I would love for it to be a place where they would want to freely give but that risk-taking behavior is so difficult in middle school level developmentally. So how you work with that in the steps toward that I honestly don't know. Definitely it is a desire that I see that more but I've used all the techniques I know. (Coaching Transcript, 9/18/13)

Because discourse can take place in pairs, small groups or the large groups, I continued to seek more clarification concerning Jill's goals for student discourse. She clarified that student participation in the whole group setting was her area of concern as follows:

> The biggest one is getting kids to freely talk versus me saying, "you don't have a choice and so you are going to talk." Which is good and it's better than not letting them talk but it is just like I would love it if it would not be me making you. Because a lot of them get it and I'll talk to them one-on-one and they show me they get it but then you add in the whole group of peers and everybody is silent. (Coaching Transcript, 9/18/13)

I decided to further explore what concerns were keeping the teacher from having students take responsibility for explaining the mathematics targeted by the lesson. Jill revealed that she wanted to be sure the students received a full explanation of the math as follows:

> And that's what I mean by them doing more and me doing less, me doing less talking and them doing more talking and summarizing versus me going over it after them making sure all the holes are filled. I'd love to see them do even more. The problem is until they're freely talking that's not going to fully happen because it's my job to make sure that they're getting what they need to get. (Coaching Transcript, 9/18/13)

Because the communication standard in the PSSM (National Council of the Teachers of Mathematics, 2000) stressed the importance of students reporting their thinking and providing evidence, I decided to follow Jill's lead by emphasizing this topic. Getting students to participate in the reporting out session was a complex interaction of implementation of questioning techniques, use of mathematical vocabulary, encouraging student discourse by having students revoice each other's explanations and asking questions of each other. I will address the topics of questioning techniques and the use of mathematical vocabulary later in this section. I made the decision to address revoicing and having students ask questions of each other using two resources describing action research projects.

There were two chapters I decided to use to facilitate our discussion on students' discourse with other students in whole class groups from the book *Promoting Purposeful Discourse* (Herbel-Eisenmann & Cirillo, 2009), "Revoicing: The Good, the Bad and the Questions" (Krusi, 2009), and "Math Is about Thinking: From Increased Participation to Conceptual Talk" (Gronewold, 2009). The following interaction on aspects of the Krusi article addressed revoicing and how it occurred in the classroom:

Coach: I wanted to go back to the idea concerning when they are asked if they understand what this other person said and explained, and I also think there's something else about it in here where the students are asked to revoice what another student said.

Teacher: And that's part of what I did today with the agree/disagree. I would ask two people and if they both said the same thing. I'd ask the second person to explain why they did what they did, and then the first person who I asked would have to revoice their answer and indicate if they wanted to add anything more to it. So that's what I started playing with today. If they disagreed, I'd have both of them explain their reasoning and have at least one other person chime in to try to get to a consensus.

(Coaching Transcript, 10/14/13)

Jill thought the students did a good job revoicing what other students said, when prompted by the teacher (Coaching Journal, 10/14/13). When Jill called on students to give explanations, she described them as responding with explanations and demonstrating a willingness to ask questions of each other (Coaching Journal, 10/16/13).

Jill found the Gronewald (2009) article less helpful because she perceived it as representing ideas that paralleled her current thinking. Instead, Jill's interest was piqued by multiple references to an article the author had cited, one that discussed conceptual versus computational approaches to mathematics instruction (Thompson, Philipp, Thompson, & Boyd, 1994). Gronewold's primary emphasis was on the importance of encouraging students to give a more extensive explanation of the procedures they used to solve a mathematical task versus only giving a numerical response to a question.

I also decided to use a video clip as a model of how a student can explain their work to the whole group. This example modeled the student taking responsibility for the explanation of his thinking rather than having the teacher elicit the explanations using numerous questions. Rather than focusing on the student's role in communicating his thinking, Jill focused on the lack of participation of other students in the interchange:

> I think it is important that they share their knowledge but that is such a rich task but he may have at the end, after all of the group shared, and brought in that class discussion. Of course, not seeing the whole clip, I don't know but there are so many areas for really rich discussion in there about all these different connections.
>
> (Coaching Transcript, 2/14/14)

While Jill did not address the level of ownership of the knowledge the student demonstrated as he presented his findings, Jill conducted the next lesson I observed in a way that gave the students in the her class ownership of their knowledge similarly to the example in the video. Her role in the reporting out session changed as the students dominated the discussion and Jill was more of a facilitator in the next observed lesson (Lesson Observation, 3/4/14). She described the lesson as follows:

> They continue to do a lot of discussion pieces because they're getting much more comfortable with challenging each other and not being hurt or offended by it so that's been really nice so I've been allowing them to be able to take over a little bit more. At one point yesterday I felt more like a referee.
>
> It makes my day whenever we have a math argument break out and most of the kids are okay with that. There is one or two that are like, what are we doing? But the rest of them are actually okay with it and can be kind of silly with it sometimes

but there are good things going on. The other interesting thing that I've seen develop out of all of this which I want to continue and encourage is actually seeing more of a willingness to help each other. Almost a pride when they're able to figure it out and wanting to share that with others versus before like, way before the beginning of the school year where some of them almost felt like it was a burden to have to help the kids who were struggling. And now it's like an excitement for them to be able to share what they have learned and what they know and definitely there's more ownership over their knowledge. (Lesson Observation, 3/4/14)

Getting students to participate in the whole group setting was very challenging. I made coaching decisions by listening to the teacher's descriptions of lessons when students were reluctant to participate and lessons in which students were more willing to volunteer. I then sought research-based materials that would shed light on the dynamics of the classroom.

During the coaching sessions, I made ongoing decisions on what to address based on Jill's concerns. The teacher asked numerous open-ended questions so I decided to analyze how the questions were impacting the lessons. I looked for patterns and analyzed ways questions and phrases that elicited in-depth responses could be a part of Jill's pedagogy.

Questioning techniques. The pedagogical practice that dominated Jill's practice was the amount of teacher talk, usually in the form of questions that occurred during the lessons. On 9/12/13 (Coaching Journal) I commented that, "The teacher left little opportunity for students to explain their thinking in the larger group." In a later coaching journal (9/18/13) entry, I described the lesson, "In this lesson, the teacher did the majority of talking and students gave short answers. Discussion of their thinking occurred in the small groups." And again, in my journal (1/27/14), I wrote, "This lesson was dominated by teacher

explanations, questions and comments." I compared this approach to classroom discourse described in research (Ball & Cohen, 1999; Forman, 2003; Lampert & Cobb, 2003)—the teacher facilitated the discourse as students explained their thinking to other members in the class.

During the first coaching session, Jill expressed her frustration with student explanations as being dependent on her questions in the following excerpt from the coaching session:

> I think the other thing that I would like to figure out is, the students do know a lot but it feels like they are still dependent on my questions. And my questions give nothing away like "where do you look" or "what does that mean?" but it's like they need those bridging questions to get a full, complete answer. And I would like to get them out of that especially in testing situations, as they get older. They're not going to have someone asking those questions and they need to give that complete answer. I don't know how to get them out of that. I think they become dependent on my questions that, once again, have no information in them except that you're not done yet. (Coaching Transcript, 9/18/13)

In my journal, I noted that, "She reiterated her frustration in trying to get the students to talk. Jill has a tendency to fill in the silence with questions" (Coaching Journal, 9/28/13). I decided to use the same video clip I described in the section on student participation, where a student was standing by the white board on which his solution was written, and he was explaining his solution. I chose to use the video because it showed a student taking responsibility for explaining a solution in a whole group reporting out session, thereby

providing a model for Jill's practice. During the student's explanation, the teacher asked

questions of the student. Jill analyzed the interaction:

> What I saw was the teacher probing the student's thinking when he was upfront,
>
> which was really good. I think he did a good job with asking him what he meant,
>
> accepting his answers. I think the teacher and I have issues with, because I noticed
>
> with my questions, I do it and he did it here, too, which is we automatically restate
>
> our questions in two different ways before we give the kids time to answer instead of
>
> stating it once, seeing if there is confusion and then restating it if we need to if there
>
> was confusion. I do that a lot, and even here (referring to a list of questions used in a
>
> lesson) and a lot of the lines of my questions are the same (Coaching Transcript,
>
> 2/24/14).

My goal was to have the teacher ask questions or make statements that would elicit

more detailed explanations of their thinking. Jill frequently asked, "Why?" or "How do you

know?" but the resulting answers tended to be short answers rather than detailed

explanations. For example, when asked why the side length of a square with the area of 2

square units is the square root of two, the student answered because the square root of two

times the square root of two is two. An example of a more conceptually based response is

one that includes how to find area, a connection to the Pythagorean Theorem, or the

relationship to a whole number example like the side length of a square with the area of four.

This analysis and comparison informed my decision to isolate the questions from the

rest of the transcript beginning with the October 16, 2013 classroom observation. In the

coaching session, we discussed the number of questions asked, and Jill responded, "I didn't

know I asked so many questions" (Coaching Transcript, 12/12/13).

My response was to first provide Jill with a way to analyze her questions using a system developed by Boaler and Brodie (2004) question categories as described in the book, *Five Practices for Orchestrating Productive Mathematics Discussions* (Smith & Stein, 2011) but later accessed the original Boaler and Brodie paper as a way to better understand the categories as they related to reform mathematics. The questions categories ranged from those that were more procedural to those that involved student understanding, participation and connections to real world applications. After analyzing and categorizing Jill's questions, I decided to comment on the number and generic nature of Jill's questions and challenge her to make her questions more specific and to contextualize them:

> I then challenged Jill to make her questions more specific using the mathematical vocabulary so instead of asking, "How do you know" I encouraged her to expand the question and gave her an example of "How do you know this is an exponential and not a linear equation?" This phraseology encourages more explanation and helps students to identify aspects of equations that make them different. Jill listened as I talked about ways to use questions as a way of increasing student participation. (Coaching Journal, 12/12/13)

I noted in my journal that, "Isolating the questions Jill asked from the rest of the transcript helped her to get a better picture of her questioning patterns" (Coach's Journal, 2/24/14). This approach enabled us to then classify the questions using Boaler and Brodie's (2004) system as a way of analyzing tendencies to use certain categories of questions. During the final questionnaire interview, Jill described her progress in using questioning when she stated:

I've gotten better about asking broader questions. Many of the kids are now offering their thinking versus me having to pull it out of them. They got really good about this because most of the eighth-graders will just say it now, because they're there without me having to prompt. (Interview, 3/26/14)

The decision to approach questioning in the classroom was driven by analysis of the lesson observation transcripts and discerning a pattern. Then, in coaching sessions, Jill and I used the information from a book chapter (Smith & Stein, 2011) where I learned more about how she perceived her questioning patterns. I made suggestions as a result of that discourse.

The topic on which our perceptions diverged was teaching techniques used to promote the use of mathematical vocabulary. The teacher thought that using student and textbook glossaries was adequate to support their making sense of and using the vocabulary. Coach/teacher discourse on this topic illustrated how using a discursive approach can uncover perceptions and help a coach and a teacher arrive at ways to address the topic. That process is the topic of the following section.

Negotiation of divergent views. Early in the coaching conversations, I brought up the topic of how to make the mathematical vocabulary a part of student discourse (Coaching Transcript, 9/28/13). When giving explanations or descriptions of mathematical concepts or procedures during group discussions, students would use non-specific terms like *it* and *stuff* rather than invoking the associated mathematical term. Jill would say, "We call that what?" and the student would respond with the applicable term but Jill acknowledged that, in general, students found it difficult to incorporate mathematical vocabulary into their oral language. She stated that there is the expectation that they use the vocabulary in their written reflections (Coaching Transcript, 9/28/13).

Jill encouraged students to access vocabulary during the lessons using the glossary in the textbook or the glossaries they created in their individual math binders. She expressed frustration with this practice in the following excerpt:

> Unfortunately a lot of them don't choose to access it so that's something we are working on, is using our resources that are in front of us and so when we do vocab, we talk through it as a class it gets written in binders, we reword it. (Coaching Transcript, 9/28/13)

I suggested using a word wall, but I noted that there was very little wall space available and Jill responded, "Yeah, that's why we don't do word walls. That's why they have their glossaries. That's my compromise, basically a word wall on paper in their hands" (Coaching Transcript, 9/18/13).

Her response provided the information for my decision to try the following two activities as a way to help Jill incorporate pedagogy that addressed vocabulary, discuss ways in which students accessed specific mathematical vocabulary as they participated in small group and whole group settings, and provide an example of action research on discourse. My comments and suggestions were grounded in the research on the use of mathematical vocabulary (Sfard, 2002; Sfard et al., 2002; van Oers, 2002), the research on how ELLs can be supported in their learning of academic mathematical terminology (Khisty, 2002; Moschkovich, 2007) and on mathematics discourse (Herbel-Eisenmann, 2009b).

Jill and I discussed how mathematical vocabulary was addressed in the classroom (Coaching Transcript, 9/18/13). Because several of the students were ELLs at the time this study was undertaken, I pointed out that the use of specific mathematical vocabulary was especially important as students may have had a mathematical idea but were reluctant to try

to express their thinking because they did not have facility with the mathematical vocabulary (Khisty, 2002). According to Sfard (2002), Sfard et al. (2002), and van Oers (2002), knowing mathematics is being able to invoke the use of mathematical terms, use the signs associated with mathematical ideas and being able to provide an explanation of the processes and strategies used to explore solutions to authentic tasks. Jill addressed vocabulary by stressing the importance of student use of specific mathematical vocabulary in their oral explanations so the other students could better understand their explanations (Classroom Observation, 10/16/13).

I conjectured that using specific words in context would help students to better explain their thinking, which could, in turn, affect their willingness to give voice to their thought processes. I decided that developing and suggesting additional ideas for incorporating vocabulary into student oral language were needed to support Jill's efforts. Based on the classroom observation (9/11/13) I suggested developing a routine where the students would have their binders open to their glossaries during lessons, or that Jill could write the mathematical terms germane to the lesson on the board at the beginning of the lesson.

During the coaching session (10/30/13), Jill said there was limited table space so the students would not be able to have their notebooks open during the lessons. I said, "I just had thoughts about the vocabulary that you anticipate they would need to use during a lesson and putting that up on the board and say, as you're explaining the concept, these are some words you might use" (Coaching Transcript, 10/30/13). Jill considered the suggestion but she responded, "I think that idea is, I'll be honest, it's not something that I think I'll consistently do. No, I just know me. I'm not usually organized enough to do that

consistently" (Coaching Transcript, 10/30/13). The remainder of the portion of the coaching session that addressed the importance of developing mathematical vocabulary consisted of my explaining the importance of students using the mathematical vocabulary in context orally as well as in writing and Jill listening. At this time, since Jill was not responding with alternate ideas, I decided to leave the topic and revisit it in later coaching sessions. This gave Jill time to think about the topic and develop alternate ways to address vocabulary. I was frustrated by her lack of response but was also challenged by it.

In the coaching session (11/06/13) Jill said:

What I'm going to try to do with this one is to see what the responses are, each of them will get a list of the words that I expected them to use because they have all the words in their glossary already. But they're just not choosing to use them, I can give them the list of the words that they used throughout these two assignments. These are the words that they should be using. If that improves the use of vocabulary in the writing more consistently and with the hopes of, or if they're using it in writing that they will start to use it in their verbal communication because I do want the concepts to be more important, it's just that their conceptual understanding is more easily seen if specific vocabs are used. But especially with them being ELLs, I don't want to get them so caught up in trying to use a right word versus trying to communicate.

(Coaching Transcript, 11/06/13)

While Jill and I did not agree on ways to support the students' use of mathematical vocabulary in their oral explanations, Jill tried to use techniques that she thought she could incorporate into her teaching.

As a coach, I decided that the teacher's ideas concerning the development of vocabulary was an area on which we disagreed and that I would continue to insert comments on the importance of the use of mathematical vocabulary but not pursue specific pedagogical methodology. For example, during the coaching session I said:

> I talked a little bit about that challenge of vocabulary and you were talking a little bit earlier about knowing vocabulary but not concepts. Can you come up with any other thoughts or ideas about how or ways to bridge that using the vocabulary without the vocabulary becoming the focus and overshadowing, maybe, process? (Coaching Transcript, 11/06/13)

This placed the responsibility for addressing the issue on the teacher by heightening her awareness. This decision resulted from using teacher responses to determine when to not actively pursue a topic but, instead, refer to the topic when appropriate in other contexts. One way Jill did decide to address vocabulary was to develop a reference sheet for the students to use for the next unit, *Growing, Growing, Growing* (CMP) (Lappan et al., 2009) that included unit objectives as well as a list of vocabulary words specific to that unit. When reviewing the sheet with the students, she said:

> I also gave you a head start, and the vocabulary words that you will need for this unit are also written on there, so when we come across them we will put them in our glossary, as we always do, but you have them there this time around. Where do you think this should go? In your binder and I want you to put it in the very front. (Classroom Observation, 11/14/13)

Throughout the coaching process, I based my comments and questions on applicable research literature so Jill would have the information on which to base her decisions concerning the role of vocabulary in knowing mathematics.

<div align="center">**Research Literature and Teacher Practice**</div>

Another way I made decisions concerning the content of the coaching sessions was first, by gathering data on Jill's practice during an initial observation and then comparing the data to mathematical teaching practices described in NCTM's PSSM (National Council of the Teachers of Mathematics, 2000), CCSS-M (Common Core State Standards Initiative, 2010), and the Mathematics Observation Protocol (Appendix C). Second, I analyzed the data gathered from the lesson observations and transcripts throughout the research project and compared it to research on reform mathematics pedagogy.

Initial Observation

The following section includes a description of the first lesson observed in this research project (Classroom Observation, 9/11/13) and my analysis of the lesson. In the analysis, I identified possible topics to be addressed in the coaching sessions.

Description of initial observation of a math lesson. The first classroom observation served as a baseline and provided the data for the first two coaching sessions. The lesson was an introductory one where students were given an example of how to find the area of a rectangle using an area of 100 square units. The teacher used questions to elicit the terms used to identify the dimensions of a rectangle—length and width and then asked students how to find area. One solution given was to draw in 100 boxes, another was to multiply length and width. The students remained at their tables and Jill asked individuals for possible dimensions and then recorded each student response on the board.

In their small groups, students were then challenged to come up with as many possible dimensions of a rectangle with an area equal to 21,800 square units. Jill called on students and followed each of their answers with non-specific questions including: What else did you get? Anything else? What did you get? Anything not on the board?

She then directed her students' learning by focusing attention on ways to check for the divisibility of 21,800. In a teacher led interaction, students responded to direct questions to determine if all whole number solutions had been identified. Subsequently, she asked each table if they had a set of dimensions not listed on the board.

The next task was described by the teacher as follows:

So what you are going to do today is to start looking at this relationship and start seeing what patterns it creates when we graph them and can you find an equation for it. So you are going to do two rectangles or two areas. One area is 24 square inches and the other area is 32 square inches. For each one, you are going to make a table, make a graph and find the equation.

Students then worked in their small groups and Jill went from table to table making comments on how the groups were interacting with each other, answering questions or instead of answering, referring students to others at their table to help them find answers. Questions asked by Jill referred to: constants, variables, setting up the graphs, the type of equation they had uncovered (not linear). The groups all successfully graphed the equation with an area of 24 using their equation; width equals 24 divided by length. The groups repeated the activity with a constant of 32.

When the groups had finished the equations, tables and graphs, Jill turned on the document camera and asked the groups to volunteer to bring their tables to be displayed on it

and to explain how they filled in their table. One group gave their paper to the teacher who put it on the doc camera and the student explained how his group had arrived at their answers. Then Jill asked for volunteers from the other groups to share their graphs. One group volunteered and the student who brought the paper up was asked to describe the graph while Jill then revoiced the student's responses. The remaining two tables were then asked to show their equation. One group volunteered and Jill asked the student, "Why did you decide that? Why did you say that?" She then asked the other students in the class, "Did you guys do that?"

When the sharing out was completed, Jill led a whole class discussion whereby the graphs were compared—what was the same, what was different. She asked students to clarify or extend their responses and she revoiced their answers. The responses were a few words in length as they described similarities in the graph lines as being curved, similar in shape. The differences noted were the length of the lines and the placement on the graph. The similarity was the shape of the line.

Coach's analysis of the classroom observation. I analyzed the baseline classroom observation using the Mathematics Classroom Protocol (Appendix C). For the baseline data, Jill had a copy of the protocol, but she and I had not reviewed it together and she did not specifically design the lesson to incorporate the characteristics as described in the protocol. The protocol has a rating scale from 1 to 5, 5 being the highest rating for a teacher, and includes a description of the characteristics of a mathematics lesson that incorporates classroom discourse and English Language Learner (ELL) strategies. I did not report Jill's ratings to her because she may have perceived that she was being judged; instead, the ratings were used by me to inform coaching ideas and actions to help focus Jill's analysis of how her

current practice related to the characteristics delineated on the Mathematics Classroom

Protocol (Appendix C) that aligns with reform mathematics as described in the CCSS-M

(2010) and NCTM's PSSM (2000).

The first area detailed in the protocol was intellectual support. In the lesson described

above, the teacher rated a 4—intellectual support from the teacher was clearly positive. Jill

was effective in this area and, in the small groups, there was intellectual support among

students for their peers. The teacher conveyed high academic expectations for all, mutual

respect, and encouraged students to try hard even if they might fail. The coaching

opportunity in this area concerned ways students could play a greater part in reporting out by

leading the discussion of the tables, graphs and equations rather than primarily responding to

the teacher's questions.

The second area in the observation protocol was depth of knowledge and student

understanding. The lesson observed was an introductory lesson and did not have a highly

complex task to be solved but Jill did construct and deliver the lesson in such a way that the

students sustained focus on a significant topic during the lesson, students demonstrated their

understanding by arriving at reasoned, supported conclusions as described on the protocol

rating of a 4. During the debriefing of the lesson, Jill thought that the only way she could

have improved the lesson was to have had more time. I wondered if more time would have

resulted in extending the lesson to include making predictions of the graph lines of rectangles

with other areas. The coaching opportunity was to explore ways to use time in a way that

ensured students were able to explore the most meaningful mathematical concepts.

The third area was mathematical analysis. The lesson had at least one major activity

in which students engaged in mathematical analysis. The part of the lesson where students

developed a table, equations and graph for the given areas and then compared the two sets of data fulfilled the requirement. The rating for this lesson is 4 because the lesson design did not include material that would engage students in mathematical analysis for the majority of the lesson.

The fourth area was mathematics discourse and communication. I rated the lesson a 4 in this area, as there were many sustained episodes where students were developing collective understandings of the mathematics in the small groups. Jill walked around the room and made comments to groups to encourage meaningful discussion and ensure that each student participated and were brought into the discussion by other members of the group. I identified a need to provide increased opportunities for sustained explanations and interactions between students in the reporting out portion of the lesson.

The fifth area was student engagement. In this lesson, the engagement was widespread with occasional off topic episodes so I rated it a 4. Most of the students were taking the lesson seriously and were trying hard. In this area, the coach saw an opportunity to explore and develop the idea of who in the class has the authority and takes ownership of the ideas.

The sixth area was academic language support for English Language Learners (ELLs). I rated the lesson a 4 because Jill used two ESL strategies during the lesson: revoicing and encouragement of the students' first language in the small groups. Coaching in this area would focus on student use of specific mathematical vocabulary as they elaborated on the mathematics in classroom discussions.

In the coaching session that followed the baseline observation, I reviewed the protocol described in the previous section with the teacher. The goal was to orient the teacher

to lesson characteristics that would constitute a mathematical lesson that aligned with NCTM recommended standards (National Council of the Teachers of Mathematics, 2000). The protocol served as a guide for future lesson planning and implementation.

Coach Analysis Informed Research-based Resources

I analyzed the coaching and lesson observation transcripts as a way to identify pedagogical patterns and then compared them to research on reform mathematics. The research on teaching mathematics provided a lens through which to view Jill's current practice to research based practice. I located sources that addressed the aspects of teaching Jill and I decided to explore in the coaching sessions. I described the type of resource I was looking for in my coaching journal (9/17/13) as follows, "Because Jill has a very busy schedule, I am reluctant to chose an article that is lengthy and very researchy; instead, I think an action research book chapter on revoicing in Herbel-Eisenmann and Cirillo's book, *Promoting Purposeful Discourse* (2009), on revoicing will resonate with Jill." In the following section, I will present examples of ways research informed decisions on classroom discourse and questioning techniques.

Discourse. During a coaching session I provided information on the importance of discourse:

> You are acquainted with Vygotsky's theoretical framework, *knowing* really occurs in its most effective form when there is discourse, when verbiage is given to concepts versus just writing or being recipients, instead, you actually have to explain something. It becomes more understandable and real. (Coaching Transcript, 9/18/13)

I revisited the importance of discourse in a later coaching session:

What we've found in using discourse is if students can say it out loud, say that and

explain the concept out loud to the class and to each other, and then justify their

comments, that they have a greater understanding of the material. (Coaching

Transcript, 10/30/13)

Jill indicated that she knew the value of discourse in making sense of the mathematics, which

was evident in the way she orchestrated and facilitated small group discussions. On 9/18/13

(Coaching Journal) I noted, "Student-to-student discourse took place in the small groups."

On 10/30/13 (Coaching Journal), I wrote, "The actual small group work was very productive,

students were engaged and talking about the mathematics and how to figure out the areas of

the squares, her explanations to the small groups did work well." Subsequent comments

made in the coaching sessions echoed these comments; work in small groups was

consistently productive.

I conjectured that discussing ways Jill encouraged student discourse would focus her

attention on what was occurring in her lessons. In the coaching session (10/14/13) I asked

Jill, "Was there anything that stood out in the students' discourse either in the lesson

observed or the subsequent lesson?" Later in the same coaching session, I referred to a

portion of a research-based book chapter (Krusi, 2009) where the author described a method

she used to help students evaluate their contributions in the reporting out sessions:

There is something else that she (Krusi, 2009) talked about, bringing in her students

and asking them what they thought would make a good classroom discussion, and this

implies that willingness and ability to take time to not just talk about the, what's going

on in math but the social and mathematical norms, as the discussion and the process

occurs in the classroom. So what do you think about that approach in working with students to be part of the discussion on participation?

I continued to address discourse as noted in my coaching journal:

I kept in mind the importance of discourse, as Jill would talk about her practice. By describing practice that she thought worked well, Jill would likely try to incorporate what she had learned as she reflected on and analyzed her teaching. (Coaching Journal, 2/14/14)

In our last coaching session I commented on how her practice reflected NCTM standards as follows:

I do have to say that period where the students were given a great deal of responsibility and, and it was just magical how they work through it, you did so many wonderful things when you said let's take a look at the board. Do all those 4 look the same? You were doing such a good job that really helping them develop those skills and thought patterns to analyze what they're looking at, looking for patterns, looking for consistency and then when they were able to correct their misunderstandings and really analyze it, I think they learned so much in that period in that class. That, to me, that's what NCTM is talking about where they look at student participation in all the things that they've done and being able to explain it and you didn't do it for them. You had them go through it and figure it out and it wasn't just the more capable kids that participated in that either. I saw all levels of kids really challenged by that task with the way he presented that. So those are some of the overarching observations. (Coaching Transcripts, 3/13/14)

Using the research on discourse informed our analysis and provided a resource on which to model practice; the work was not simply based on opinion or personal experience. Our resources on questioning techniques in general and questioning techniques used to promote mathematical understanding also provided information on which to base teaching and coaching decisions.

Questioning. Promoting classroom discourse that explores mathematics deeply depends on questions and statements that orchestrate classroom conversations where students explain their thinking and provide evidence on which they based their solutions (National Council of the Teachers of Mathmatics, 2000). I decided to use the book *Learning to Question and Questioning to Learn: Developing Effective Teacher Questioning Practices* (Dantonio & Beisenherz, 2001). While not focusing on mathematics, the research strived to address questioning as it related to conceptual understanding. I summarized the main points as follows:

The strategies that this author talks about, and it will be similar to some of the ones in the chapter we just copied from *The Five Practices for Orchestrating Productive Mathematics Discussions* (Smith & Stein, 2011), are *collecting strategies* where students are asking questions, observing and recalling. And then there are *bridging strategies,* this is that second level of exploration in which they are starting to think about a problem and going back to that which they've already learned that might help them. Does it compare to their problem, what is similar or different, or a different way of looking at something they have already learned, by grouping the ideas that might help them to solve the problem. And then, as they continue to solve the problem, they moved to *anchoring strategies,* which include labeling that which they

learned and then moving it into an equation; they are gathering those ideas and

organizing them and then making an equation or generalizations that they can apply

to other things. (Coaching Transcript, 1/14/14)

The next resource I provided to Jill was *The Five Practices for Orchestrating Productive*

Mathematics Discussions (Smith & Stein, 2011), a resource I referred to earlier in this

chapter. I decided that this resource would help Jill analyze the questions she was using and

provide examples of questions that would facilitate their discourse. In preparation for the

coaching session, I described how I used the question categories as a basis for our discussion:

I went through the transcript and tied some of the questions Jill asked to the question

types in the chart from the *The Five Practices for Orchestrating Productive*

Mathematics Discussions (Smith & Stein, 2011) book. Then I challenged her to

come up with questions that were more specific and might lead students to give more

details concerning what they were thinking. She listed several questions that were the

ones she typically used that went across lessons on the different types of equations.

(Coaching Transcript, 1/21/14)

As we continued to discuss the questions she typically used (from Coaching

Transcript, 1/14/14), I suggested ways to contextualize her questions by basing the question

on what the students had already done as a way of having the student extend the explanation.

For example, rather than only asking a student to describe the differences in how the lines

looked in a linear equation and an exponential equation, asking them specifically what

characteristics of the equations accounted for those differences.

In summary, the examples of how research on discourse and questioning informed the

coaching sessions detailed above demonstrate the use of research and research-based

materials to inform the coaching sessions. I made decisions beginning with the research on reform mathematics pedagogy, compared Jill's practice to what the research had shown and then chose materials I thought would resonate with her. Because of her positive response to the materials, and her desire to read more of the book than the chapters I provided, I bought her a copy of *Promoting Purposeful Discourse* (Herbel-Eisenmann & Cirillo, 2009) and lent her my copy of *Learning to Question and Questioning to Learn* (Dantonio & Beisenherz, 2001).

Summary

In this chapter, I have presented qualitative data in an attempt to answer the research question, "How does the coach make decisions when coaching a middle school teacher on mathematics discourse?" In the process of analyzing the data, four major themes emerged: (a) beliefs, mathematical content knowledge and pedagogical content knowledge; (b) development of rapport and trust; (c) teacher responses and comments in the coaching sessions; and (d) research literature and teacher practice. I then described the themes and provided evidence elicited from the data sources. The results indicated that decisions made by the coach in a coaching relationship are complex, inter-related, iterative and particular to the teacher. In the next chapter, I will discuss the results of the research and implications of the findings.

CHAPTER 5

DISCUSSION AND GENERALIZATIONS

As an aid to the reader, this final chapter of the dissertation restates the research problem and reviews the methodology used in the study. Conjectures made prior to and during the research are discussed. The remaining sections of the chapter summarize the results and discuss their implications.

Research Problem

The primary purpose of this study was to better understand the ways decisions were made by a mathematics coach when working with a mathematics teacher on classroom discourse. *Curriculum and Evaluation Standards for School Mathematics* was published in 1989 (National Council of the Teachers of Mathematics, 1989), a document that called for a marked change in teaching mathematics, an approach referred to as reform mathematics. A paradigm shift was needed to move a nation of teachers from teaching mathematics with an emphasis on memorizing and applying algorithms to produce one right answer to an approach in which students would explore mathematical concepts thereby learning mathematics with understanding. Coaching has evolved as an approach used by many educational institutions as a means to help teachers move from traditional teaching methods to methods that reflected reform mathematics principles (Barkley, 2010; Joyce & Showers, 2002; West & Staub, 2003). This research study is situated in the research on mathematics coaching and attempts to answer the question, "How does the coach make decisions when coaching a middle school teacher on mathematics discourse?" In the next section, I will review the methodology discussed in chapter three.

Methodology

This research used design experiment methodology, a qualitative method that Brown (1992) conceived of as a way to innovate in a classroom, as a means to develop learning theories that would inform educators, learning theories that would be useful because they were empirical studies of what actually occurred in a setting similar to those of many classrooms. Cobb et al. (2003) elaborated on design experiment methodology to include the process of and support for learning in the classroom. This methodology enabled me, the coach/researcher, to conduct the research in the educational environment in which the discourse took place and to develop generalizations that addressed the decision-making processes of a coach as she worked with a teacher.

The data was gathered from teacher questionnaires, classroom observations, audio recordings of the teacher's comments made during the lesson, audio recordings of the debriefing and coaching sessions, field notes and the coach's journal. Transcripts were made from the recordings and those transcripts were given to the teacher to enable her to revisit the classroom and coaching sessions. Baseline data was gathered—initial questionnaire and classroom observation—followed by four cycles consisting of a classroom observation, review of transcripts and reading or viewing identified resources and then a coaching session followed by an analysis of that session. Plans for the next classroom observation were made at this time. Data analysis occurred continuously during the research project as a way of informing the interventions that evolved from the data.

Data was analyzed using open, axial, and selective coding (Strauss & Corbin, 1998) The first step of the data analysis was open coding; I assigned terms to the data and looked for categories. The next step was axial coding in which the questions "why or how come,

where, when, how, and with what results" were used as a way of determining relationships among categories; the themes emerged as a result of axial coding. The final step was selective coding resulting from this data analysis. Selective coding produced the generalizations and will be discussed later in this chapter.

<div align="center">**Summary of Results**</div>

As I analyzed the data, four themes emerged in the research that informed the coaching decisions I made: (a) beliefs, mathematical content knowledge and pedagogical content knowledge, (b) development of rapport and trust, (c) teacher responses and comments in the coaching sessions, and (d) research literature and teacher practice. Each theme affected the other themes; decision-making was complex because of the interactive aspects of teaching and learning, and the characteristics and nature of the people and processes involved in the coaching relationship. In this section, I will address the themes that emerged when I analyzed the data.

Beliefs, Mathematical Content Knowledge and Pedagogical Content Knowledge

Ascertaining Jill's entry point on the continuum of beliefs, mathematical content knowledge and pedagogical content knowledge informed my decisions on coaching content. Gaining insight into her beliefs around teaching mathematics, level of mathematical knowledge and pedagogical content knowledge was essential for a productive coaching relationship (West & Staub, 2003). Gathering this background data informed me as to what issues were influencing teacher discourse and pedagogical techniques. Jill indicated that she was very well prepared in her content knowledge in mathematics and in her beliefs about teaching mathematics that aligned with the NCTM's PSSM (National Council of the Teachers of Mathematics, 2000) and CCSS-M (Common Core State Standards Initiative,

2010). Analysis of Jill's pedagogy by both Jill and me, and ways it reflected her beliefs provided the information I needed to make decisions concerning topics for the discourse in the coaching sessions. Coaching involves change and that can be difficult so I decided to monitor Jill's responses as I developed rapport and trust in the coach/teacher relationship as a way to ensure that the experience was productive and Jill was engaged in the process.

Development of Rapport and Trust

I decided that it was important to build rapport and establish trust with the teacher because she was letting another educator into her teaching world making her susceptible to being hurt, personally or professionally (Hull et al., 2009; Evans, 1996; Marris, 1986). Going into the coaching setting, I did not initially realize how important this aspect of coaching was, but quickly learned during the coaching sessions and in analyzing the transcripts that development of rapport and trust and providing ongoing encouragement were essential to a productive coach/teacher relationship. As a way of establishing trust, I assured Jill that I had her best interests in mind and was not there to judge her but to help her improve her practice as a way of improving student achievement. While I cannot identify any specific action or indicator when I thought trust had been established, I think it was around six months into the research project. At this time, it appeared that many of the changes we had been discussing were being phased in to her teaching practice. In addition to building rapport and trust, I decided that additional ways of relating to the teacher were needed: being supportive, being empathetic, providing reassurance, and acknowledging progress. Having a positive relationship enabled Jill and me to work together. I also decided that working collaboratively to identify topics acknowledged Jill's ability to reflect on and identify areas of practice she wanted to change. My knowledge and experience enabled me to identify areas

that research has shown to impact student learning. Teacher agency with respect to the identification of areas to address in coaching sessions was a significant aspect of this research (Brookfield, 1986; Hull et al., 2009; Knowles, et al., 2005).

Teacher Responses and Comments in the Coaching Sessions

My experience in working with adults has led me to employ an approach that builds on effective practices demonstrated by a teacher; expand on what is working and modify what does not produce desired results. I decided to use this approach with Jill. I first identified aspects of her practice that reflected those described in the Mathematics Observation Protocol (Appendix C). As Jill and I discussed her practice in coaching sessions, we collaborated in identifying topics that she wanted to address and we negotiated divergent viewpoints when we differed in our perceptions of what constituted effective practice. I made decisions as a result of this discourse, on what questions to ask and resources to use to create cognitive dissonance relative to her current practice as a way to promote reflection on possible ways to change lessons to better support student learning.

In order to make decisions concerning coaching, I analyzed the lesson observation transcripts to determine what was occurring in classroom instruction and then I analyzed the coaching transcripts to determine how Jill perceived her practice relative to her goals. Jill identified topics including voice intonation, student participation in large group reporting, and use of questions and phrases that promoted student participation and interaction. I identified use of mathematical vocabulary development and use in oral presentations as a topic based on research in mathematics education in general and also on mathematics education for ELLs (Forman, 2003; Khisty, 2002; Moschkovich, 2007a; Sfard, 2002). Because all of these topics affected classroom discourse, I was able to decide what

techniques to discuss and what research-based resource materials to use in the coaching

sessions as a way of helping Jill influence the classroom discourse.

Research Literature and Teacher Practice

I based my decisions concerning what to address in the coaching sessions and what

resources to use on the relevant research literature (Kilpatrick, Martin, & Schifter, 2003;

Kitchen, DePree, Celedon-Pattichis, & Brinkerhoff, 2007; National Council of the Teachers

of Mathematics, 2000; Yackel & Cobb, 1996) as it applied to Jill's teaching practice and the

coaching conversations, research that was written in a way that was accessible to her. I made

the decision to address Jill's established patterns that she followed in her lessons, patterns

that she deemed to be effective, patterns that she experienced as having embodied the

essence of reform mathematics. Jill and I engaged in discussions based on book chapters or

videos and then considered possible ways the information given could help Jill alter those

patterns and accomplish her pedagogical goals. She indicated that much of what we read

reinforced what she was already doing or had already tried. We worked collaboratively as

we sifted through the information to find ways of teaching that would impact her classroom,

ways that were compatible with her personality and teaching style. The reform mathematics

based curriculum and materials chosen by the school were research-based but there is more

to effective teaching than implementing the materials as delineated in the teaching materials.

It made sense to me to use the coaching relationship to connect classroom practice

with research. Lengthy research articles may be difficult to understand and it can be

challenging to discern how to incorporate the findings. Lack of time is another factor in

teachers not accessing the research (Cordingley, 2008). As a coach, I decided to connect Jill

with resources she may otherwise not have accessed.

In summary, I have discussed the four themes that emerged in the research that influenced the way I made coaching decisions: (a) beliefs, mathematical content knowledge and pedagogical content knowledge; (b) development of rapport and trust; (c) Teacher responses and comments in the coaching sessions; and (d) research literature and teacher practice. Each theme intersected with and influenced the others. I decided that, in the coaching sessions, we would explore what occurred in the lessons, analyze and reflect on aspects of the discourse and compare it to what we thought would advance student learning. We discussed research as a way of understanding what was happening as compared to the Mathematics Observation Protocol (Appendix C), PSSM (National Council of the Teachers of Mathematics, 2000) and CCSS-M (Common Core State Standards Initiative, 2010). Jill continued to be engaged in the coaching process because we had established rapport, trust and other supportive processes as a way of building confidence as she made changes in her practice as was emphasized in coaching literature (Barkley, 2010; Dantonio, 2001; Hull et al., 2009; Knight, 2009; West & Staub, 2003). We both identified topics around the use of discourse in the classroom we wanted to discuss in coaching sessions. I supplied research-based materials to help us analyze Jill's practice and inform us as to ways to make changes to achieve Jill's goals. The next section is a discussion of the results.

Discussion

Design experiment methodology incorporates the use of conjectures as a way to design interventions based on that which is evolving during the research project. In this section, I will first discuss the conjectures made prior to and during the research, researcher insights and the subsequent generalizations, and the resulting theory. Additionally, explanations of the factors related to the research process, the coach's experience in doing

the research, and implications for coaching and recommendations for further research are detailed.

Conjectures

   The teaching of mathematics resides within the context of the school and national standards. The school in which the research was done chose a curriculum and materials that aligned with reform mathematics and adhered to standards delineated in PSSM (National Council of the Teachers of Mathematics, 2000) and CCSS-M (Common Core State Standards Initiative, 2010) (Fieldnotes, 9/1/13). Prior to the first coaching sessions, I decided to make conjectures concerning possible ways Jill would be challenged to implement reform mathematics, conjectures that were based on my experience observing math teachers as they implemented reform mathematics and on what I had read in research studies (Herbel-Eisenmann & Cirillo, 2009; Kilpatrick et al., 2003). I first wanted to determine ways Jill's practice reflected those standards. My findings would inform the content of the coaching sessions. In my research, I made six conjectures, three initial conjectures prior to conducting the research and three conjectures while conducting the research on the following topics: (1) timing of teacher support, (2) student exploration of mathematics, (3) vocabulary and mathematics communication, (4) context for the coaching sessions, (5) student willingness to explain their thinking in the large group, and (6) ways of encouraging student discourse.

   Timing of teacher support. The first conjecture that informed my coaching decisions was based on Smith's (2000) research that focused on a teacher's dilemma concerning the importance of allowing students to struggle when problem solving versus the importance of ensuring student success. I conjectured that Jill might not be willing to let students struggle to find the answer but would provide supports before they had a chance to

delve into the mathematics themselves. In our first coaching session, Jill addressed this topic (Coaching Session, 9/18/15). She noted that, as students attempted to solve tasks, she tended to signal whether students were right or wrong before they provided evidence supporting their solutions. Jill wanted to make her intonation more neutral because she wanted the students to work on solutions until they were confident of their results. Over the course of the coaching sessions, she reported her progress by saying:

> And they're starting to depend less on me to know if they are right or wrong because I have been trying to do my best to continue on the road and not giving it away by my intonation, and that has been helpful and fun. (Coaching Transcript, 12/12/13)

Student exploration of mathematics. The second conjecture that informed my coaching decisions was based on Ball's and Bass's (2003) research in which the researchers found that students developed their understanding of mathematics through exploration rather than from teacher led explanations. I made the decisions on ways to address this topic based on the classroom observations—each observation resulted in ideas concerning what to say in the coaching sessions, and ways to encourage change without discouraging Jill. Additionally, I determined what resources to use to address student exploration through the use of discourse, including lesson observation transcripts and book chapters. I embedded suggestions in the coaching discourse as a way of bringing increased responsibility to the students for the presentation of solutions by saying, "What do you think about comments made in this chapter about students listening to each other and not relying on the teacher's comments (Coaching Transcript, 10/14/13)?" and "Were there some activities on the subsequent day (after the lesson I had observed) that gave the students the opportunity to lead the discussion about what they were learning (Coaching Transcript, 10/30/13)?"

I made the decision by analyzing Jill's comments in a coaching session (9/18/13), to capitalize on Jill's desire to have the students explain their thinking to the large group. Throughout the project, I encouraged Jill to move the students to the front of the room to explain the math. During the last observation (3/14/14), she transferred the responsibility of reporting the processes used to solve a task in the large group setting to the students. I commented:

> The first part of it, students were tasked with figuring some things out at their tables, and then you assigned each table a problem that they were going to be responsible for and, during that period, when you actually look at the transcript, as opposed to just the questions that we're looking at here, you'll see a lot more phrases rather than questions that include things like tell me about it or explain what you're doing as opposed to questions that range from broad to specific. (Coaching Transcript, 3/14/14)

Vocabulary and mathematics communication. I made the decision to explore how Jill was addressing mathematical vocabulary with her students based on the information that Jill provided at the beginning of the research project indicating that most of the students in the class were ELLs at the time of the research. My third conjecture was that a bridge connecting concepts with vocabulary would improve communication. Khisty's (2002) and Moschkovich's (2007a) research addressed issues concerning the relationship of language and learning mathematics for Latina(o) students who are ELLs. Students may struggle with words that have multiple meanings, or move between using Spanish and English. Jill addressed student use of mathematical language by relying mainly on the writing portion of the lessons as a way to have students learn to use the vocabulary; students would write

definitions of mathematical terms in their own words in their notebook glossaries and they would explain their solutions to problems in writing. I did not analyze student work to determine how effective her practice was, but I thought extending Jill's approach to include using terms in oral explanations would help students become more comfortable using unfamiliar mathematical terms. I wrote down my thoughts in my coaching journal as follows:

> When asked about students providing evidence to support their thinking, Jill said they do it in their written answers. I asked if they read their answers aloud—Jill said they first discuss the problems as a group then they write it down. I thought that reading what they wrote aloud would help them get used to saying the mathematical words aloud and giving evidence. (Coaching Journal, 10/14/13)

Students' use of mathematical terms when explaining concepts was an area in which Jill and I had to negotiate our viewpoints of what works when facilitating the incorporation of applicable terms in student explanations. The way I made the decision that this topic was important to pursue was, the research stressed that to know the mathematics is to be able to communicate mathematically (Sfard, 2002) and the research on ELLs supported the practice of making explicit and clarifying mathematical terms and their multiple meanings as they make sense of the math (Khisty, 2002). While one researcher, Moschkovich (2007a) stressed the importance of students making sense of the mathematics using language they know as way of explaining their thinking conceptually, eventually, it is important that terms used by the mathematics community are seen as useful in expressing their thinking. Jill was concerned that stressing the learning of the vocabulary may have inhibited student willingness to explain their thinking. My thought was that hearing and seeing the vocabulary would help students, over time, to associate their ideas with the vocabulary—not to have the

vocabulary become a prerequisite to the exploration or explanation of the mathematics. Our viewpoints were referred to in a coaching session when I said:

> I talked about the challenge of vocabulary and you were talking earlier about knowing vocabulary but not concepts. Can you come up with any other thoughts or ideas about how or ways to bridge that explaining using the vocabulary without the vocabulary becoming the focus and overshadowing, maybe, process? (Coaching Transcript, 11/06/13)

Jill was concerned that eighth graders tend to be self-conscious and were more willing to use unfamiliar language in writing than orally. I thought she was accurate; based on what Jill said, I decided that scaffolding their oral use of terminology, not as a way to inhibit their explanations, was a way not only to help them remember the terms but also the associated mathematical content. During the research, I made three additional conjectures and will refer to them using ordinal numbers in the interest of continuity.

Context for the coaching sessions. My first three conjectures focused on topics I thought Jill and I would discuss in the coaching sessions sometime during the research project. When I began the research, I made the fourth conjecture; information concerning the teacher's beliefs, mathematical knowledge, and pedagogical content knowledge about teaching mathematics was needed to establish the context in which coaching would take place (Ball & Cohen, 1999; Bartiromo & Etkina, 2009; Gates, 2006; Shulman, 2004; Skott, 2009). In the initial questionnaire (Appendix A), Jill's responses were consistent with reform mathematics principles and having the mathematical content knowledge (MCK) needed to enact that curriculum. I decided to focus on topics that were determined collaboratively and through negotiation that emerged in the area of pedagogical content knowledge (PCK). The

research on professional development stressed the importance of relevant rather than generic professional development opportunities that may have little meaning to the participants (Birman, Desimone, Porter, & Garet, 2000; National Commission on Teaching for America's Future, 1996). Discerning where Jill was positioned in relationship to beliefs, MCK and PCK provided the information I needed to determine the entry points into the coaching process.

Student willingness to explain their thinking in the large group. The fifth conjecture I made was that using specific words in context would help students to better explain their thinking, which could, in turn, affect their willingness to give voice to their thought processes in the reporting out sessions. When Jill and I were discussing how students struggled to explain their solutions in a way that others clearly understood their thinking, I said:

> And then on line 206, you refer to the vocabulary needed to be successful in this unit
> and so you have been explicit about that and that helps them to clearly communicate
> what they're thinking and it also builds their feelings of competence and pride of
> being understood. (Coaching Transcript, 12/12/13)

As a result of her comments, I decided to connect the idea of moving from conceptual understanding to the use of applicable vocabulary as a way to increase student willingness to report out in the larger group. This conceptual strand ran through every coaching session.

Ways of encouraging student discourse. The sixth conjecture that informed my decisions was that discussing ways Jill encouraged student discourse would focus her attention on what was occurring in her lessons. To accomplish this goal, I decided to isolate the questions from the rest of her discourse. Together, we analyzed the types of questions she asked using a system developed by Boaler and Brodie (2004). Because questioning

dominated the lessons, this decision made it possible to center our attention on a specific aspect of teaching and then analyze and reflect on our findings. For example, questions could be used for orienting and focusing students in relationship to a mathematics problem or they could be used to promote student discourse.

In summary, making conjectures was an aspect of design experiment methodology that enabled me to provide coaching that was not prescribed but instead was designed to respond to the teacher and classroom events as the research progressed. I started with initial conjectures that informed the direction of the research in the first stages of gathering data. I then went on to develop conjectures based on lesson observations, coaching sessions and debriefing sessions. Each conjecture guided my decision-making in my quest to make the coaching sessions meaningful for Jill; I accessed research-based resources, videos, shared personal experiences, and guided her through analysis of her practice. The conjectures were used to inform the coach as to possible interventions that could influence teacher discourse in the classroom.

Researcher Insights

Determining how a coach made decisions evolved over the period of time the research took place. Working collaboratively, the teacher and I attempted to make sense of what was occurring in the classroom as we strove to understand each other and how we each perceived how teacher utterances in the student/teacher discourse impacted our goals. My decisions evolved from the analysis of what the teacher said and responded to in the coaching sessions and what the teacher did in the classroom. I reviewed that data using selective coding—this analysis occurred between the data and the analyst as it described the reality

revealed by the data. From this analysis, broader ideas were revealed and then developed into generalizations.

   Generalizations. In this section, I describe the generalizations I developed based on the data, the analytic memos, and the diagrams as a means to answer the research question, "How does the coach make decisions when coaching a middle school teacher on mathematics discourse?" I challenged myself to make that which is familiar strange, to explore multiple explanations for what the data revealed, and implement member checking as a way of obtaining feedback for my conclusions. The following generalizations reflect the selective data analysis:

1. A coach makes decisions on the content of coaching sessions by determining where the teacher is positioned in relationship to her pedagogical goals for classroom discourse.

2. A coach makes decisions by determining what type of and frequency of support is needed to keep the teacher engaged in the change process.

3. A coach makes decisions by comparing what is occurring in the classroom and coaching sessions to relevant educational research.

Generalization 1: A coach makes decisions on the content of coaching sessions by determining where the teacher is positioned in relationship to her pedagogical goals for classroom discourse. Pedagogical goals were developed based on the teacher's beliefs, mathematical content knowledge, pedagogical content knowledge, teacher identified goals and coach identified goals. As Loucks-Horsley and Matsumoto (1999) found in their review of professional development research, "A study of the practices of experienced professional developers conducted by the National Institute for Science Education (NISE) found that each

situation that calls for teacher learning requires a unique design that combines elements of effective professional development in different ways" (p. 268). Locating the teacher's position in relationship to national standards (Common Core State Standards Initiative, 2010; National Council of the Teachers of Mathematics, 2000) and research on discourse (Forman, 2003; Vygotsky, 1978) and more specifically discourse in mathematics classrooms (Cazden, 2001; O'Conner, 1998, Sfard, 2002) formed the basis on which we began the coaching. Determining where the teacher was positioned in relationship to a version of socio-constructivist theory, the *emergent perspective* (Stephan et al., 2003) as it applied to her students informed the coach where to start coaching conversations. The *emergent perspective* melds the constructivist viewpoint (Piaget & Inhelder, 1969) with the sociocultural perspective (Vygotsky, 1978) as a way to consider the individual aspects of learning with the social interactions that occurred in the classroom, both of which contributed to student learning.

The *emergent perspective* also applies in the coaching environment in that the teacher is constructing knowledge in the social context with the coach. Through these interactions, the coach responded to the teacher's perceptions of her current practice and together, they identified ways to bridge the gap between that and desired practice. Ways of accomplishing the goals were socially constructed between the coach and the teacher. This is an example of learning using the zone of proximal development (Vygotsky, 1978), whereby the coach represents the more knowledgeable other and the teacher extends what she knows with the help of the coach. Additionally, teacher agency was important in this relationship (Brookfield, 1986; Knowles et al., 2005).

Adult learning theory applies in a coaching relationship; identifying teaching goals collaboratively reflects the principles of andragogy. This was exemplified in the coaching transcript (9/18/13) in which Jill identified a topic she thought was important as a means to improve her teaching.

> My goals for discourse are just that they'll just be more free with it. I feel that right now I have to push them a lot I would love for it to be a place where they would want to freely give but that risk-taking behavior is so difficult in middle school level developmentally. So how you work with that, in steps toward that I honestly don't know. Definitely it is a desire that I see that more but I've used all the techniques I know.

She was struggling with ways to engage students in large group discourse and expressed her need to know more about techniques to change the current practice she employed in conducting a classroom lesson.

The andragogical model of adult learning (Knowles et al., 2005) consists of six principles: (a) need to know, (b) learner's self-concept, (c) learner's experience, (d) readiness to learn, (e) orientation to learning and (f) motivation. Teachers want to participate in professional development that applies to their situations or to aspects of teaching they want to address (Loucks-Horsley & Matsumoto, 1999; National Commission on Teaching for America's Future, 1996); they want coaching to be contextualized thereby reflecting their teaching style, characteristics of their students, and aspects of their educational organization. The sixth principle of andragogy, motivation, or, from the coach's perspective, ensuring that the teacher continues to be engaged in the change process, is viewed as essential to change (Fullan, 2007; Fullan & Miles, 1992).

Generalization 2: A coach makes decisions by determining what type of and frequency of support is needed to keep the teacher engaged in the change process. The personal relationship between the coach and the teacher undergirds the coaching process. Research-based coaching models described getting to know the teacher, establishing rapport, and building trust as a beginning step in building a coaching relationship (Barkley, 2010; Joyce & Showers, 2002; West & Staub, 2003). My data showed that building that relationship at the beginning was important because making changes can be very difficult (Evans, 1996; Marris, 1986). I found that relationship building went beyond the initial stages and needed to be nurtured in multiple ways to keep the teacher engaged and willing to continue her participation in the process. At the start of the research project, I made decisions around building rapport by recognizing Jill's efforts to become the teacher she was; she was confident and her practice embodied many of the teaching techniques developers of the CMP program (Lappan et al., 2009) recommended.

At the beginning of our relationship, there was a tendency to focus on the surface aspects of teaching and on positive, effective practices as a way of establishing rapport. As familiarity increased and trust was built, the lesson analysis went deeper and we made more progress. In our case, the initial change Jill chose to work on was voice intonation as a way of encouraging more detailed explanations. As Jill began to perceive me as a resource to help her explore aspects of her teaching, she identified topics she wanted to explore, topics that were more challenging. Jill was able to audition techniques in class before implementing them during the lesson I would observe, a way of building confidence as she tried new approaches. When discussing a lesson, I would comment on specific examples of her

practice that exemplified stated goals as a means providing assurance and acknowledging progress as demonstrated in the following exchange.

> Jill: But they're still struggling when it comes to the group and them leading it themselves. I am still the main questioner, effectively, by asking them to ask questions. So asking them do you agree or disagree, not necessarily giving my input but asking them for theirs.
>
> Coach: Yeah, so maybe they need some permission around that. Some of the things that I looked at reflect what we've talked about and that is the way, and the verbiage that you use when you're encouraging them to look at the process and really explain their work.

By specifically noting progress, Jill was likely to continue the practice we discussed. I also thought it was important to be empathetic when lack of time and imminent deadlines interfered with her readings and analysis of transcripts. In my journal, I made a note concerning the October 30, 2013 coaching session:

> This coaching follows a classroom observation on October 16, 2013. Due to staffing issues, behavior issues with students and doing report cards, Jill did not have time to review the transcript or read the article. Jill took time to scan the transcript of the lesson during the coaching session.

Had I pressured her to spend more time preparing for our coaching sessions, she may have chosen to discontinue her participation! The affective aspects played an important role in the coaching process.

Discourse that addressed affective aspects of the teacher/coach relationship was designed to motivate the teacher. Fullan (2007) described a theory of action for change

knowledge that emphasized the necessity of motivation without which any efforts to change practice will fail. Lewin's change theory (Kritsonis, 2005) emphasized unfreezing, a way of creating an opening for change to take place. The coach's development of rapport and trust, and being supportive in multiple ways during the duration of the research as changes were made in the teacher's practice as a way of keeping the teacher engaged positions my generalization within the research on change.

The goal of coaching is to institute change. In this research, the teacher and coach pursued topics that the larger body of educational research has determined to be an important part of learning mathematics.

Generalization 3: A coach makes decisions by comparing what is occurring in the classroom and coaching sessions to relevant educational research. The knowledge amassed in educational research is essential to moving teaching forward as a way to improve student learning (Cordingley, 2008). Changes in practice need to take place in response to the research, not as a result of unsupported opinions. After the baseline data was gathered, I located action research done by teachers in a book on classroom discourse (Herbel-Eisenmann & Cirillo, 2009). I decided to use teacher written chapters because I thought they would resonate with Jill; they were not lengthy, nor did they use verbiage that would be unfamiliar to Jill. Reading a teacher's account of her experience positions the ideas closer to a classroom setting, albeit different from Jill's classroom, and further from a more abstract view and interpretation of the research. From a constructivist viewpoint, the closer the ideas to be learned are to what is already familiar to the learner, the easier it is to relate and to build new knowledge (Knowles et al., 2005).

While the first book chapters we read helped Jill and I establish a common ground for our discussions, I think there was a turning point in the coaching process that occurred when we read the chapter in Smith's book (Smith & Stein, 2011). There was a framework (Boaler & Brodie, 2004) that provided the means to categorize the types of questions Jill asked. The process of isolating the questions and analyzing the classroom observation transcript using this technique seem to enable Jill to better understand what her patterns were and also realize how much of the class was made up of her questions versus questions and comments that supported and encouraged the explanation by students of procedures used to solve the given tasks. When I asked Jill about questioning techniques she was using as a result of coaching, she responded as follows.

> Jill said she was doing more connecting and probing. While she said she couldn't remember what she did last time with respect to the types of questions, she said she had the students do a lot more explaining, more probing rather than them just filling the holes.
>
> I noted that there were a lot more 5's which was generating discussion among students. When asked about linking and applying, Jill said that would occur in later lessons. (Coaching Journal, 3/14/13)

From this experience, I learned that narrowing the focus to a portion of a transcript and having specific characteristics on which to concentrate helped Jill to better analyze her work. This is an example of moving from a broader to a more narrow view of her practice after identifying patterns.

In the last classroom observation (Classroom Observation, 3/14/14) there was clear change in the way the teacher was conducting class and especially in the group-reporting

portion. I noted in my journal (3/14/14) that she served more as a facilitator in this lesson and intentionally set up the classroom reporting out situation in a way that the students took more responsibility for explanations and also were willing to question one another and ask for additional explanations. This was particularly important because having students report out in that large group, giving in-depth explanations, and having them question each other was the area we discussed the most extensively in coaching sessions.

Theory

In the previous section, three generalizations emanating from the data were described, (1) a coach makes decisions on the content of coaching sessions by determining where the teacher is positioned in relationship to her pedagogical goals for classroom discourse, (2) a coach makes decisions by determining the type of and frequency of support needed to keep the teacher engaged in the change process, and (3) a coach makes decisions by comparing what is occurring in the classroom and coaching sessions to relevant educational research. The three main ideas around coaching decisions can be summarized as individualizing the coaching process, providing support that will keep the teacher engaged in the coaching process, and using research-based materials and interventions as resources to inform the trajectory of the changes. While this study was limited to one coach and one teacher, a modest theory suggested by this study and the research described in chapter 2 would be that the effective coach makes decisions concerning classroom discourse by using applicable research to inform the trajectory of the coaching process as determined by the individual needs of the teacher.

While this theory does not provide a blueprint for making coaching decisions, it becomes part of the research on coaching as a means to change teacher practice. It also

stresses the importance of the role of educational research as a resource to be accessed by coaches. And finally, the teacher's individual needs guide the coach with respect to support required for the change process and support to move the teacher from her current practice to her desired practice.

This research explored the decisions made in the coaching environment as the coach facilitated the teacher's reflections on her practice and subsequent changes she made in her pedagogy. The study was important but had limitations.

Explanation of the Factors Related to the Research Process

This section describes factors relating to the research process including limitations, and a description of the coach's experience.

Limitations. To understand where this study resides in the general corpus of educational research, it is informative to do a formative assessment of this design experiment. I will discuss replicability, design issues, and data analysis.

Replicability. It would be difficult to replicate the study as the setting was unique. It was in a small private school whose director was a university math professor and many of the students were English Language Learners at the time of the study. Additionally, the coach had extensive experience in education having been a mathematics teacher, principal, and director of curriculum, and was also a doctoral candidate. Few content-focused coaches will have had that level of experience and education.

Design issues. The study was limited in that there was only one participant. While the teacher was not a certified teacher, she had worked with a university professor and had taught mathematics for five years but, arguably, the decisions made by the coach could have been different if the participant had been a certified mathematics teacher. Having additional

teachers from other schools in the study would have provided more data on which to base the generalizations. While member checking occurred in the coaching sessions, a journal kept by the teacher would have given a more detailed viewpoint of the participant's experience.

Analysis of transcripts. The teacher struggled to find time to spend on reading and reflecting on what occurred in the observed lessons. I would have liked to spend more time with the teacher to analyze the classroom observations together as a way to explore underlying meanings of her utterances, patterns of discourse, and intentions she had for her comments in more depth.

As the coach, I struggled to focus on the decision-making aspect of the research question and would often use the analysis of classroom observations and coaching sessions to assess the responses to coaching sessions. I continually had to remind myself to use the analysis as a way to determine why and in what ways I was making coaching decisions. Ultimately, the research provided information useful to the educational community to fulfill the need for continual professional development to its practitioners.

Coach/researcher experience. In this section, I will discuss the challenging and rewarding aspects of the research.

Challenges. There were three aspects that were particularly challenging. One, I tended to focus on the results of the coaching process; I had to constantly remind myself that I needed to discern how I was making the decisions. Two, I had unrealistic expectations concerning the rate at which changes would occur and three, Jill's responses to some of my suggestions were different from what I expected.

While focusing on the results of the coaching session provided information I used to make decisions, I had to focus on how the information influenced my decisions as a coach.

As an administrator, the part of my work I enjoyed most was working with teachers to improve their practice. Much of what I did during this research project was to focus on Jill's pedagogy; I spent a great deal of time analyzing the transcripts and notes on the observed lessons and on the transcripts of the coaching sessions because I wanted to identify what the teacher did well and ways to help her be even better. I also wanted to figure out ways to promote buy-in for teaching approaches I was advocating. I had to continually remind myself to use a metacognitive approach to analyze why I made the decisions I made.

Prior to working on my doctorate, I was an elementary school principal and a director of curriculum for a school district. I was in a position of authority and because the relationship with the teachers was evaluative, there was a tendency for them to comply with my suggestions. As I entered into the coaching relationship, I was naïve in my expectation that my suggestions for change would immediately be embraced and implemented. The following journal entry describes Jill's reaction to suggestions concerning ways to incorporate vocabulary, a reaction I had not anticipated.

> In the next section of the coaching session, I tried to elicit ideas on how to facilitate student use of vocabulary orally. Jill stuck to the idea of students using their glossaries, which, she explained, they never do but she just needs to remind them. She rejected suggestions as something she just would not do. She did not have any ideas about other ways to help students access the vocabulary. As I continued to talk about the importance of vocabulary and different ways of approaching it, Jill would just say, "Mm Hmm." (Journal entry, 10/30/13)

I had hoped that Jill would engage in discourse with me around the idea of vocabulary use but, instead, she withdrew.

In my previous position of authority came the expectation that people would implement programs I advocated or developed. As anyone in education knows, that expectation is not always fulfilled but often times people were more willing to comply when the person suggesting the changes was in a position of authority. I also had recent coursework and research experience. While I had more extensive experience than the teacher, the coaching relationship was voluntary and collaborative; the teacher decided what methods she was willing to implement in her classroom. In the collegial relationship, even with a more knowledgeable other, the teacher was the one who decided what she was willing to try in her classroom. I was naïve in thinking that the ideas for change would always be welcomed!

The rate of change also was different than I had expected; there were numerous coaching sessions before I observed significant change. I addressed this in the following journal entry.

I also realize that our relationship is in an adjustment period and that what happens in the coaching sessions reflects the other challenges Jill has in life and as the on-site director. When a person has a lot of other things on their mind, reflecting on their practice may be seen as a luxury—instead, they are just trying to get through the day. Jill seems to be very preoccupied and stressed. I want to make progress but it may be slower than I had hoped. (Coaching Journal, 10/30/13)

The readings provided tools with which to analyze practice and the videos provided visual representations of techniques I wanted Jill to implement but it took time for Jill to process the information and audition the changes in classes prior to my observations. For example, I described Jill's progress in my journal entry on December 12, 2013 as follows, "I asked Jill

how this lesson transcript was different from the previous lesson. She thought it wasn't much different but thought the students were more comfortable speaking in a whole class session."

In the last lesson I observed (3/14/14), many of the pedagogical concepts we explored were implemented. I noted that the lesson incorporated much of what we had discussed in coaching sessions in my journal.

Overall, this lesson demonstrated an approach to teaching where the students talked more, were encouraged to engage in a conversation with each other and owned the solutions they had developed. Students were asked to restate what others said or were encouraged to ask each other for clarification. (Coaching Journal, 3/14/13)

Seeing the progress in the classroom observation brought to mind the rewarding aspects of the project.

Rewarding aspects of the project. I also found three aspects of the research to be very rewarding. The first aspect was participating in discourse with Jill as we analyzed and reflected on her teaching and ways of meeting student needs. Second, observing ways Jill incorporated new approaches in her teaching was rewarding and third, watching students change from reluctant participants to students who engaged in actively reporting their mathematical thinking to their peers was encouraging.

Participating in discourse with Jill on aspects of teaching was especially interesting. While classroom discourse was the main topic, we discussed other aspects of teaching including gender and cultural issues, classroom management, and real world projects. The teaching process is so complex and multi-faceted; there are so many topics to explore and techniques to try out to get the desired response. For example, when Jill was struggling to

motivate one of her students to give more detail in his explanations, we discussed ways to approach this student's specific needs.

I enjoyed observing Jill as she grappled with ways of getting the eighth grade students to participate in the large group sessions. Her rapport with students was friendly and encouraging, she used humor to relate concepts and to get students to talk. As Jill changed her questioning techniques to using questions and phrases that would elicit more detailed explanations, I sensed her feeling of accomplishment when students would elaborate on their thinking. In the last classroom session I observed, she related her pleasure at seeing students engage in discourse with each other as they explained their solutions and then asked one another to further clarify or defend their solutions.

I found the research process to be very compelling; taking part in the larger community of researchers gave significance to my limited study. I realized the importance of each contributor to the larger body of knowledge (Brown, 1992). It is challenging to understand the nuances of classrooms and the more research that is done, the more we learn about the process of teaching and learning.

Implications for Coaching

In this section, I will discuss the two main implications for coaching, time and resources, and qualified coaches. Then, I will discuss ways to leverage time and resources to support coaching efforts. Finally, I will note the importance of having realistic expectations concerning the time needed for change.

First, in educational organizations, there is a perpetual tension between time and resources needed to plan and prepare for daily instruction and time and resources needed for continual professional development including reflection on one's practice. This tension is

present in the coaching setting as a coach and teacher are challenged with carving out time to

dedicate sufficient attention to current practice, research findings, decisions concerning

desired changes and opportunities to implement those changes. Second, it is important to

have a qualified coach to provide expertise in areas of demonstrated teacher needs (National

Commission on Teaching for America's Future, 1996). The direction taken in coaching

sessions result from the many decisions, large and small, made by the coach. The breadth

and experience of the coach will influence progress made by the teacher.

Time and resources. Time is needed to (a) build relationships, (b) identify topics,

(c) implement new practices, (d) locate and read research-based selections, and (e) integrate

ideas to provide a basis for sustainable change.

Build relationships. This study demonstrated the importance of establishing and

maintaining a relationship throughout the coaching process and the extensive amount of time

needed to build rapport and trust, and to provide continuous support for the relationship.

Meaningful dialogue, including critique of practice, is unlikely to occur between relative

strangers or if teachers feel as if they are being judged (Halai, 1998; Murray et al., 2009).

The coach, to accomplish the goal of improving teaching practice and student learning, is

tasked with keeping the teacher engaged and motivated to participate in seeking and applying

ways to become a more effective teacher. When a teacher perceives the coaching process to

be beneficial to her and her students, she is likely to persist when confronted with

suggestions for change and to work through topics in which she may lack confidence

(Shulman, 2004).

Identify topics. Multiple observations provide information needed to identify and

determine possible topics to be addressed in the coaching sessions. From the chosen topics,

those that have the greatest chance of improving student learning are prioritized. Because of the complexity of teaching mathematics, and the multiplicity of possible entry points into the process of coaching, determining the most beneficial ways to make significant progress becomes centrally located in the learning process. It is a waste of valuable time to coach a teacher in areas in which she is knowledgeable, a practice found in pre-planned professional development presentations. Addressing individual needs maximizes the change for meaningful progress.

Implement new practices. When I was a principal, teachers expressed feelings of frustration when they were expected to make changes in several aspects of their teaching such as increasing student discourse, using real-life tasks to learn and apply mathematical concepts, to encourage exploration of mathematics rather than tell students how to solve problems. This study demonstrated that the teacher needed time to analyze her practice relative to that described in reform mathematics documents (National Council of the Teachers of Mathematics, 2000), digest new information, try out ways of implementing change and make adjustments to fit the practice with her personality, teaching style and students. It took several months for the teacher to make core changes in ways she conducted math lessons.

Locate and read research-based selections. Resources that resonate with the teacher need to be accessed (Cordingley, 2008; Huberman, 2002). These resources vary from individual to individual depending on their experience, strengths and areas of desired change. For example, a beginning teacher may want to read articles that communicate explicit practices to implement in her classroom while a teacher who is working on a master's degree may want to read more detailed research articles. Time for reading, discussing and digesting

the information and then speculating on how the emerging ideas can be applied to the classroom is crucial. Discourse between coach and teacher to make sense of the information is essential to melding the ideas with practice.

Integrate ideas to provide a basis for sustainable change. In this study, much of the time spent in the early stages included gathering information, determining current practice and prioritizing topics. Only minor changes were made initially. Multiple observations, coaching sessions, and information garnered from reading selections preceded the more significant changes made at the end of the study. The many ideas put forth in literature and coaching sessions needed to be integrated with current practice ultimately resulting in changes leading to desired practice. To accomplish this, a highly qualified coach is essential in a coaching model of professional development.

Qualified coaches. The coach is well positioned to provide professional development if she has extensive pedagogical experience, mathematical content knowledge, and experience with adult learners. In the case of mathematics, one study (Anstey & Clarke, 2010) found at the outset of the research, the coaches wanted more professional development in how to be effective coaches. At the end of the study, they indicated that they needed more mathematical knowledge to be effective coaches. While both aspects of coaching further the coach's knowledge, knowing the mathematics helps coaches to support teachers in their understanding of how to help students as they conceptualize the mathematics, develop creative and unconventional ways of solving tasks, and communicate their thinking. The mathematics coaching process is best served by having a well-qualified coach.

Leveraging time and resources. A district or school can leverage financial and staffing resources to carve out time needed for effective professional development by

combining the use of professional development funds with creative staffing in a manner that would provide regularly scheduled time for coach/teacher meetings, for reading research-based materials, and for planning ways to experiment with alternate ways of teaching. Available financial resources may be needed to compensate teachers to extend their hours or days to participate in meaningful professional development, or to fund staffing patterns that release teachers from classroom duties.

For example, a permanent substitute could provide one extra hour per week in a middle school setting, an hour designated as a coaching session. In elementary settings, back-to-back music and library sessions could be scheduled or three teachers could team teach two classes in a way that would allow time for each to participate in coaching sessions. This may have implications for the size of the classes but creative measures are called for—bringing in an entire staff for a professional development session has been shown to be ineffective (National Commission on Teaching for America's Future, 1996). Solutions are as extensive as the educational entities are inventive, and motivated to make coaching work.

Realistic expectations. Making significant, sustainable changes in teaching is a time consuming process. A history of changes in ways of educating our children have met with varying degrees of success (Marshall et al., 2007) up to and including changes in the architecture of schools to reflect the open classroom concept! Defining the outcomes society and business deem to be characteristic of an educated individual, aligning assessments reflecting those characteristics with instructional components and techniques that prepare students to meet the objectives will result in meeting the goals of educational systems. Considering the length of time many teachers will be in the classroom, changing teacher preparation is one component to effectuating change but a means to alter pedagogy to reflect

research findings of those teachers who are already in the classroom is an important component in educational change. While the length of time for implementing change varies by individual, it is a process that may take several years of coaching before the new ways of teaching become the new normal for the teaching. Further research is needed to better understand the coaching process.

Further Research

The findings in this study suggested that a coach makes decisions based on determining where a teacher is located in relationship to classroom discourse. This study used a questionnaire and interview to determine where the teacher was positioned relative to a reform mathematics approach. Ways the teacher described what she envisioned for her classroom provided additional information concerning classroom discourse. Further research could include several coaches working together to explore their decision-making processes in relationship to where a teacher is located on a trajectory of eliciting student thinking in classroom mathematics discourse.

The findings in this study suggested that a coach makes decisions by determining what type of and frequency of support is needed to keep the teacher engaged in the change process. A coach is determining the needs of the teacher through direct and indirect channels using their lens of what is occurring in the relationship. Further research into ways coaches make decisions in the affective domain of the coaching process could be explored by focusing on this aspect of coaching and could include the viewpoint of the teachers as they perceived their needs and ways coaches decided to respond to those needs.

Additionally, the findings in this study suggest that a coach makes decisions by comparing what is occurring in the classroom and coaching sessions to relevant educational

research. Moving research findings to the classroom has been a challenging endeavor; decisions around ways to bring current research information to practitioners can be a part of the solution. Extending this research to gather data on how numerous coaches make decisions on types of research communications (internet publications, papers, books, reports, videos, conferences) to use in their work can inform researchers and coaches on ways to make the connections to the research.

Reform mathematics changed the standards describing what it is to know mathematics (National Council of the Teachers of Mathematics, 1989, 2000) Over time, curriculum materials and professional development opportunities were designed to support teachers in their efforts to implement the standards. Moving generations of teachers from primarily teaching algorithms to teaching mathematics with understanding challenged educational systems to create ways to not only establish teacher buy-in but to undergo a paradigm shift from teacher's telling students how to do the math to facilitating students discovering the mathematics needed to solve tasks. One shot presentations, workshops, and trainings met with little success (National Commission on Teaching for America's Future, 1996).

Professional learning communities made a difference in schools when teachers participated in them in productive ways and administrators promoted their implementation. As educational systems and researchers identified a need for continuous professional development, coaching models that helped make changes in teacher practice evolved. This research focused on how decisions were made by the coach. As teachers move from the classroom to coaching positions, the importance of how other coaches have made decisions in their work with teachers may improve and expedite their work. I predict that thinking

about what and how decisions are made will result in a more meaningful coaching experience, one that positions the teacher to make a difference in student learning.

I learned that individualizing coaching is challenging. As I worked with the teacher, I had to reflect on numerous inputs, make decisions on what and what not to respond to, and determine ways in which to respond. This experience challenged me to find ways to incorporate what the teacher brought to the setting with available resources. I determined that using teaching techniques I had found to be effective with children and adults, served me well in the coaching sessions. Using the design experiment methodology enabled me to work in an environment similar to what other coaches might experience and to implement interventions that responded to what was actually happening rather than having to implement pre-planned strategies.

I found coaching to be an interactive process where both the teacher and coach explored and uncovered aspects of teaching in general and aspects of the coach/teacher experience. In particular, while there were unique experiences in coaching, there were processes that may be common to coaching in general. Research may demonstrate that decision-making is one of those processes.

APPENDICES

Appendix A

Questionnaire--Teacher Information

1. By the end of this school year, how many years will you have been teaching altogether?

Please round to the nearest whole number... _____

2. In one typical calendar week from Monday to Sunday, for how many single hours/periods are you formally scheduled/time-tabled to teach each of the following subjects?

Count a double hour/period as two single hours/periods.

Write zero if none.

Number of single hours/periods

a) Mathematics.. _____

b) General Science... _____

c) Physical Science.. ...._____

d) Earth Science... _____

e) Life Science……... _____

f) Biology……... _____

g) Chemistry... _____

h) Physics... _____

i) other subjects.. _____

3. To be good at mathematics at school, how important do you think it is for students to...

Check one box in each row.

	Not important	*Somewhat important*	*Very important*
a) remember formulas and procedures			
b) think in a sequential and procedural manner			
c) understand mathematical concepts, principles, and strategies			
d) be able to think creatively			
e) understand how mathematics is used in the real world			
f) be able to provide reasons to support their solutions			

4. To what extent do you agree or disagree with each of the following statements?

Check one box in each row.

	Strongly Disagree	*Disagree*	*Agree*	*Strongly Agree*
a) Mathematics is primarily an abstract subject				
b) Mathematics is primarily a formal way of representing the real world				
c) Mathematics is primarily a practical and structured guide for addressing real situations				
d) If students are having difficulty, an effective approach is to give them more practice by themselves during the class				
e) Some students have a natural talent for mathematics and others do not				
f) More than one representation (picture, concrete material, symbol set, etc.) should be used in teaching a mathematics topic				
g) Mathematics should be learned as sets of algorithms or rules that cover all possibilities				
h) Basic computational skills on the part of the teacher are sufficient for teaching mathematics in elementary grades				
i) A liking for and understanding of students are essential for teaching mathematics				

5. How well prepared do you feel you are to teach…

Check one box in each row.

	I do not teach these subjects	*Not very well prepared*	*Somewhat well prepared*
a) fractions, decimals and percentages?			
b) ratios and proportions?			
c) measurement – units, instruments, and accuracy?			
d) perimeter, area, and volume?			
e) geometric figures – definitions and properties?			
f) geometric figures – symmetry, motions and transformations, congruence and similarity?			
g) coordinate geometry?			
h) algebraic representation?			
i) evaluate and perform operations on algebraic expressions?			
j) solving linear equations and inequalities?			
k) representation and interpretation of data in graphs, charts, and tables?			
l) simple probabilities – understanding and calculations?			

6. What is the highest level of formal education you have completed?

Yes or No

BA OR EQUIVALENT.._____

MA/PHD.. _____

7. Do you have a teacher training certificate? _____

8. While studying to obtain your BA or equivalent or teacher training

certificate, what was your major or main area(s) of study?

Yes No

a) Mathematics.._____

b) Biology.. _____

c) Physics.. _____

d) Chemistry.. _____

e) Education.. _____

f) Mathematics Education.._____

g) Science Education... _____

h) Other.._____

9. If you have a master's degree, what was your major or main area of study?

I do not have a master's degree.._____

(Put a check on the line and skip to the next question. If you have a master's degree,

proceed to the next part of this question.)

Yes or No

a) Mathematics.. _____

b) Biology.. _____

c) Physics.. _____

d) Chemistry.. _____

e) Education.. _____

f) Mathematics Education.. _____

g) Science Education... _____

h) Other... _____

10. How many students are in your mathematics class?

Write in a number for each. Write 0 (zero) if there are none.

boys _____ girls _____

11. Do you use a textbook in teaching mathematics to your class?

Circle one.

Yes No

12. If yes, approximately what percentage of your weekly mathematics teaching

time is based on your mathematics textbook?

Check one line.

0-25%... _____

26-50%... _____

51-75%... _____

76-100%... _____

13. How many minutes per week do you teach mathematics to your mathematics class?

Minutes: _____

14. What subject matter do you emphasize most in your mathematics class?

Check one line only.

mainly number (e.g., whole numbers,

fractions, decimals, percentages, etc.)... _____

geometry... _____

algebra..._____

combined algebra and geometry... _____

combined algebra, geometry, number, etc... _____

other, please specify _____............................._____

15. In your mathematics lessons, how often do you usually ask students to do the following?

	Never or almost never	*Some lessons*	*Most every lesson*
a) explain the reasoning behind an idea			
b) represent and analyze relationships using tables, charts, or graphs			
c) work on problems for which there is no immediately obvious method of solution			
d) use computers to solve exercises or problems			
e) write equations to represent relationships			
f) practice computational skills			
g) use graphing calculators to solve exercises or problems			

16. In mathematics lessons, how often do students...

Check one box in each row.

	Never or almost never	*Some lessons*	*Most every lesson*
a) work individually without assistance from the teacher			
b) work individually with assistance from the teacher			
c) work together as a class with the teacher teaching the whole class			
d) work together as a class with students responding to one another			
e) work in pairs or small groups without assistance from the teacher			
f) work in pairs or small groups with assistance from the teacher			

17. In a typical month of lessons for your mathematics class, what percentage of time is

spent on each of the following activities?

Write in a percentage for each activity

The total should add to 100%

a) adminstrative tasks (not related to lesson's content/purpose)............. _____%

b) homework review... _____%

c) lecture-style presentation by teacher... _____%

d) teacher-guided student practice.. _____%

e) re-teaching and clarification of content/procedures.............................. _____%

f) student independent practice.. _____%

g) tests and quizzes... _____%

h) other.. _____%

Adapted from Third International Mathematics and Science Study-Repeat. (1998).
Mathematics teacher questionnaire main survey. (Ref. No. 98-0037). Amsterdam, Holland:
International Association for the Evaluation of Eductional Achievement.

Appendix B

Teacher Post-Survey

Name: _____ **Date:** _____

Please answer the following questions:

To be good at mathematics at school, how important do you think it is for

students to...

Check one box in each row.

	Not important	*Somewhat important*	*Very important*
a) remember formulas and procedures			
b) think in a sequential and procedural manner			
c) understand mathematical concepts, principles, and strategies			
d) be able to think creatively			
e) understand how mathematics is used in the real world			
f) be able to provide reasons to support their solutions			

To what extent do you agree or disagree with each of the following

statements?   *Check one box in each row.*

	Strongly Disagree	*Disagree*	*Agree*	*Strongly Agree*
a) Mathematics is primarily an abstract subject				
b) Mathematics is primarily a formal way of representing the real world				
c) Mathematics is primarily a practical and structured guide for addressing real situations				
d) If students are having difficulty, an effective approach is to give them more practice by themselves during the class				
e) Some students have a natural talent for mathematics and others do not				
f) More than one representation (picture, concrete material, symbol set, etc.) should be used in teaching a mathematics topic				
g) Mathematics should be learned as sets of algorithms or rules that cover all possibilities				
h) Basic computational skills on the part of the teacher are sufficient for teaching mathematics in elementary grades				
i) A liking for and understanding of students are essential for teaching mathematics				

After participating in the research study, how well prepared do you feel you are to teach…

Check one box in each row.

	I do not teach these subjects	*Not very well prepared*	*Somewhat well prepared*
a) fractions, decimals and percentages?			
b) ratios and proportions?			
c) measurement – units, instruments, and accuracy?			
d) perimeter, area, and volume?			
e) geometric figures – definitions and properties?			
f) geometric figures – symmetry, motions and transformations, congruence and similarity?			
g) coordinate geometry?			
h) algebraic representation?			
i) evaluate and perform operations on algebraic expressions?			
j) solving linear equations and inequalities?			
k) representation and interpretation of data in graphs, charts, and tables?			
l) simple probabilities – understanding and calculations?			

How many students are in your mathematics class?

Write in a number for each. Write 0 (zero) if there are none.

boys _____ girls _____

Did you use a textbook in teaching mathematics to your class?

Circle one.

Yes No

If yes, approximately what percentage of your weekly mathematics teaching

time is based on your mathematics textbook?

Check one line.

0-25%.. _____

26-50%.. _____

51-75%.. _____

76-100%.. _____

How many minutes per week do you teach mathematics to your

mathematics class?

Minutes: _____

What subject matter do you emphasize most in your mathematics class?

Check one line only.

mainly number (e.g., whole numbers,

fractions, decimals, percentages, etc.)... _____

geometry.. _____

algebra.._____

combined algebra and geometry... _____

combined algebra, geometry, number, etc.. _____

other, please specify _____............................_____

In your mathematics lessons, how often did you usually ask students to do

the following?

Check one box in each row.

	Never or almost never	*Some lessons*	*Most every lesson*
a) explain the reasoning behind an idea			
b) represent and analyze relationships using tables, charts, or graphs			
c) work on problems for which there is no immediately obvious method of solution			
d) use computers to solve exercises or problems			
e) write equations to represent relationships			
f) practice computational skills			
g) use graphing calculators to solve exercises or problems			

In mathematics lessons, how often did students...

Check one box in each row.

	Never or almost never	*Some lessons*	*Most every lesson*
a) work individually without assistance from the teacher			
b) work individually with assistance from the teacher			
c) work together as a class with the teacher teaching the whole class			
d) work together as a class with students responding to one another			
e) work in pairs or small groups without assistance from the teacher			
f) work in pairs or small groups with assistance from the teacher			

In a typical month of lessons for your mathematics class, what percentage

of time is spent on each of the following activities?

Write in a percentage for each activity

The total should add to 100%

a) adminstrative tasks (not related to lesson's content/purpose)............. _____%

b) homework review.. _____%

c) lecture-style presentation by teacher.. _____%

d) teacher-guided student practice.. _____%

e) re-teaching and clarification of content/procedures............................. _____%

f) student independent practice... _____%

g) tests and quizzes.. _____%

h) other... _____%

Adapted from Third International Mathematics and Science Study-Repeat. (1998). *Mathematics teacher questionnaire main survey.* (Ref. No. 98-0037). Amsterdam, Holland: International Association for the Evaluation of Eductional Achievement.
Additional questions:

In what ways did the participation in the coaching impact your practice?

What aspects of the coaching process did you find to be most beneficial? Why?

What aspects of the coaching process did you find to be least beneficial? Why?

In what ways did the coaching impact your teaching ELL students?

How did the coaching impact your math content knowledge?

What are your strengths as a math educator?

Appendix C

Mathematics Classroom Observation Protocol

I. Intellectual Support				
1 Intellectual support is **negative**. Action/comments by teacher or students result in put-downs of students' academic efforts. Students interfere with one another's efforts to learn. Classroom atmosphere for learning is negative.	**2** Intellectual support is **mixed**. Both negative and positive actions/comments by teacher or students concerning students' academic efforts are observed. Teacher fails to call upon students who want to participate repeatedly.	**3** Intellectual support is **neutral or mildly positive**. Evidence may be mainly in the form of verbal approval for student effort and work. Support tends to be given to students who are already taking initiative in the class, and it tends not to be given to those who are reluctant participants or less articulate or skilled in the subject.	**4** Intellectual support from the teacher is **clearly positive**. There is some evidence of intellectual support among students for their peers. Evidence of special efforts by the teacher take the form of expressions that convey high academic expectations for all, mutual respect, and a need to try hard and risk initial failure.	**5** **Intellectual support is strong**. The class is characterized by high academic expectations, challenging work, strong effort, mutual respect, and assistance in achievement for all students. Both teacher and students demonstrate a number of these attitudes by soliciting and welcoming contributions from all students who are expected to put forth their best efforts. Broad participation may be an indication that low achieving students receive intellectual support for learning.

II. Depth of Knowledge and Student Understanding

1	2	3	4	5
Knowledge is very thin because concepts are treated trivially or presented as non-problematic. Students are involved in the coverage of information they are to remember.	**Knowledge remains superficial and fragmented**. Underlying or related concepts and ideas might be mentioned or covered, but only a superficial acquaintance or trivialized understanding of these ideas is evident.	**Knowledge is treated unevenly** during instruction. Deep understanding of some mathematical concepts is countered by superficial understanding of some other ideas. **At least one idea may be presented in depth** and its significance grasped by some (10%-20%) students, but in general the focus is not sustained.	**Knowledge is relatively deep** because the students provide information, arguments, or reasoning that demonstrates the complexity of one or more ideas. The teacher structures the lesson so that **many students** (20%-50%) do at **least one** of the following: • sustain a focus on a significant topic for a period of time; • demonstrate their understanding of the problematic nature of information and/or ideas; • demonstrate understanding by arriving at a reasoned, supported conclusion; • explain how they solved a relatively complex problem.	**Knowledge is very deep** because the teacher successfully structures the lesson so that **most students** (50%-90%) do at **least one** of the following: • sustain a focus on a significant topic; • demonstrate their understanding of the problematic nature of information or ideas; • demonstrate complex understanding by arriving at a reasoned, supported conclusion; • explain how they solved a complex problem. In general, students' **reasoning, explanations, and arguments demonstrate fullness and complexity of understanding**.

III. Mathematical Analysis

1	2	3	4	5
1 Students receive, recite, or perform **routine procedures**. In no activities during the lesson do students engage in mathematical analysis.	**2** Students primarily receive, recite, or perform **routine procedures**. At some point, they engage in **mathematical analysis as a minor diversion.**	**3** There is **at least one significant activity** involving mathematical analysis in which some students (10%-20%) engage. OR, mathematical analysis that is primarily diversionary in nature occurs **throughout** the lesson.	**4** There is **at least one major activity** in which students engage in mathematical analysis. This activity occupies a substantial portion of the lesson; and many students (20%-50%) are engaged in it.	**5** Most students (50%-90%), **for most of the time** (50%-90%), are engaged in mathematical analysis.

IV. Mathematics Discourse and Communication				
1 Virtually **no features of mathematical discourse** and communication occur, or what occurs is of a fill-in-the-blank nature.	**2** Sharing and the development of **collective understanding** among a few students (or between a single student and the teacher) **occur briefly**.	**3** There is **at least one sustained episode** of sharing and developing collective understanding about mathematics that involves: (a) a small group of students or (b) a small group of students and the teacher. Or, **brief episodes** of sharing and developing collective understandings occur sporadically throughout the lesson.	**4** There **are many sustained episodes** of sharing and developing collective understandings about mathematics in which many students (20%-50%) participate.	**5** The creation and maintenance of **collective understandings permeates the entire lesson**. This could include the use of a common terminology and the careful negotiation of meanings. Most students (50%-90%) participate.
V. Student Engagement				
1 **Disruptive disengagement**; students are frequently off-task as evidenced by gross inattention or serious disruptions by many students (20%-50%); this is the central characteristic during much of the class.	**2** **Passive disengagement**; students appear lethargic and are only occasionally on-task; for **most** of time, **many** students (20%-50%) are either clearly off-task or nominally on-task but not trying very hard.	**3** **Sporadic or episodic engagement**; **most** students (50%-90%), **some** of the time (20%-50%), are engaged in class activities, but this engagement is uneven; mildly enthusiastic or dependent on frequent prodding from the teacher.	**4** **Engagement is widespread**; **most** students (50-%-90%), **most** of the time (50%-90%), are on-task pursuing the substance of the lesson; most students seem to be taking the work seriously and trying hard.	**5** **Serious engagement**; **almost all** students (90% or more) are deeply involved, **almost all** of the time (90% or more), in pursuing the substance of the lesson.

VI. Academic Language Support for ELLs*				
1 An explicit **intolerance** toward students' use of L1 is evident such as translation or code-switching (e.g. "We only use English in this classroom.") Students who are not yet fully proficient in English are ignored and/or seated apart from their classmates.	**2** **No acknowledgement of ELL students' needs** or presence is evident. Funds of knowledge are not incorporated. Although there is no explicit use of ESL strategies, or attention to L1 (such as explicit attention to cognates), students' use of L1 is tolerated.	**3** There is **at least one instance** in which an ESL scaffolding strategy is used to develop academic language (i.e., revoicing, use of graphic organizers). Even if teacher does not use L1, it is evident that students' linguistic repertoires are valued and that they are encouraged to build on them. At least on incident in which students' funds of knowledge is acknowledged.	**4** **Sustained** use of at least a couple of ESL strategies, such as the use of revoicing and attention to cognates, or encouragement of L1 usage is observed at least between teacher and one, or small group, of students.	**5** **Extensive and sustained** attention to students' linguistic and cultural funds of knowledge. **Deliberate and continuous** use of ESL strategies, such as gesturing, use of objects (realia), use of cognates, revoicing, graphic organizers and manipulatiaves are observed during whole class and /or small group instruction and discussions. The main focus is the development of mathematical discourse and meaning making, not students' production of "correct" English.

Adapted from National Center for Research in Mathematics Education. (1992). Wisconsin Center for Educational Research. Madison, WI: University of Wisconsin-Madison.

*Scale for *Academic Language Support for ELLs* developed by E. Rubenstein-Avila (2006), The University of Arizona.

Appendix D

Debriefing Conference Question Guide

(This serves as a guide for the coach—only questions deemed applicable will be used)

Statement of Discrepancies (Were the intended goals accomplished?)

What did you expect to happen in the mathematics lesson?

What did you plan to do in the lesson?

What actually happened when you conducted the lesson?

What issues would you like to focus on?

What do you want to focus on these issues?

What do you hope to gain from our discussion?

How will this assist you in your instructional development?

In what way was conducting the lesson different from what you anticipated?

What was different about your actions?

What were you thinking about?

Why did you change from your original plan?

What was different in the student actions from what you anticipated?

Why do you think the students responded in this manner?

What strategies did you use to address ELLs?

Analysis of Teaching Actions (Were the strategies employed as intended and were they effective?)

What did you feel you did well during the lesson?

Why do you think it was necessary for you to do that?

What were you having difficulty with?

Why do you think that was difficult or not handled as effectively as you would

have liked?

Did the discourse promote sense-making of the mathematics?

Generation of Solutions and Effects

In what way was the situation or experience problematic for you as it evolved?

Why did this bother you?

What do you think you should do to change?

If you change, what do you think will result in terms of students, you, and

future instructional events??

How do you plan to implement this change?

What problems do you think you will have? Why?

What benefits will be derived from this change?

What makes you think these benefits will result from implementing this change?

What techniques or practices would you like to maintain?

Why would you like to maintain them?

How do you think these practices impact your classroom performance?

How do you think these practices will impact your thinking about instruction, student

learning, and your future goals for developing your teaching repertoire?

What do you want to focus on next time we meet?

When would you like to meet?

Adapted from Dantonio, M. (2001). Collegial coaching: Inquiry into the teaching self.

Bloomington, IN: Phi Delta Kappa.

Appendix E

Post Conference Coaching Conversation Form

Lesson Goal:

Evidence of student learning with understanding

Evidence of student misunderstandings, misconceptions

Strategies used to make student thinking public

Instructional techniques employed to foster learning with understanding

Conjectures—develop possible explanations concerning what happened during the lesson.

Identify classroom discourse goals and identify teacher moves to achieve those goals.

List resources to assist teacher in reaching identified goals:

Appendix F

Lesson Plan

Lesson number _____ (in the sequence of observed lessons in the research study)

Date: _____ Time: _____

Lesson Topic:

Lesson Goal:

Instructional Strategies:

Textbook or other resources:

Materials:

Appendix G

Data Matrix

Coding

Action	Topic
Praising-P	Questioning-Q
Reassuring-R	Voice intonation-Intonation
Imbedding suggestions-Imbed	Vocabulary-V
Clarifying-C	Intention-Inten
Facilitating reflection-F	Student Participation-P
Assessing progress-A	Revoicing-R
Identifying topics-I	
Responding to inquiry or suggestion-R	
Describing-D	

Sample Coding Grid

Date	Action/Topic	Lines	Source	Quote
10/30/13 10/16/13	D-P-Q-Intonation	75-82	Coach Trans	I think that asking them and whatnot and helping them and scaffolding them has allowed them to be more comfortable with giving their opinions, especially since the controlling of the inflection of my voice doesn't give them hints so much that I think they feel more comfortable and I think that they get the fact that I'm questioning everything and being okay with me questioning. And hopefully that will transfer into them questioning each other.

Date	Action/Topic	Lines	Source	Quote
10/30/13 10/16/13	D-P	88-93	Coach Trans	Not too much because we were finishing this out and they did it in their tables. But they're still struggling when it comes to the group and them leading it themselves. I am still the main questioner, effectively, by asking them to ask questions. So asking them do you agree or disagree, not necessarily giving my input but asking them for theirs.
10/30/13 10/16/13	R-V	139-142	Coach Trans	I think my language can influence theirs. I definitely think that I, the idea that my patterns carry over to them and the vocabulary words don't always carry over. And the last part, what I emphasize, they emphasize, I think that is beginning to be true.
10/30/13 10/16/13	D-V	181-192	Coach Trans	I'm happy with the amount I was asking them, which is good. What stands out is my students which actually aren't on here but just the way they were willing to respond. And the first glimmer that sometimes they understand that what they're saying is making sense despite their trying, that they're beginning to realize that that doesn't make sense to others. I know what I'm trying to say but I don't understand. And then just their ability towards the end as I walk through that with them to actually be able to identify why mine was more clear than theirs. So with the vocabulary and keeping it simple using examples and I'm realizing that was very helpful to them.

Appendix H

Summary of Research Project

Research Question: How does the coach make decisions when coaching a middle school mathematics teacher on classroom discourse?
Qualitative Methodology
Design Experiment
Researcher participant--Coach

Teacher participant
     Meets with coach/researcher
     Participates collaboratively with coach in planning and analyzing lessons
     Reads agreed upon resources pertaining to teacher practice

Setting—Eighth Grade Classroom   Faith based private school
Curriculum—Connected Math Project CMP

Data Collection:
     Classroom observations
     Audio recording—Coaching sessions
     Journal—Coach/Researcher
     Memoing and field notes—Coach/Researcher

Data Analysis
     Open Coding
     Axial Coding
     Selective Coding

Data analysis occurs as the research progresses and informs the research. The process is iterative and conjectures are formulated as a means of understanding that which is being observed.
Length of research project—4 to 6 months

Appendix I

Bibliography for Teacher and Coach

This bibliography constitutes a list of books and articles, portions of which were referred to by the coach or were given to the participating teacher in this research project. Articles that were used depended on the needs of the teacher. Chapters of books and articles were chosen collaboratively and were discussed as part of the coaching experience.

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