12-2008

Transforming Teachers' Knowledge and Skills: Lesson Study In Mathematics Instruction Sensitive For Diverse Learners at Middle Level

Vessela Ilieva
Utah State University

TRANSFORMING TEACHERS' KNOWLEDGE AND SKILLS: LESSON STUDY IN MATHEMATICS INSTRUCTION SENSITIVE FOR DIVERSE LEARNERS AT MIDDLE LEVEL

by

Vessela Ilieva

A dissertation submitted in partial fulfillment
of the requirements for the degree

of

DOCTOR OF PHILOSOPHY

in

Education

Approved:

_____	_____
Dr. Jim Barta Major Professor	Dr. Jim Cangelosi Committee Member
_____	_____
Dr. Gary Carlston Committee member	Dr. Jim Dorward Committee member
_____	_____
Dr. Sherry Marx Committee member	Dr. Byron R. Burnham Dean of Graduate Studies

UTAH STATE UNIVERSITY
Logan, Utah

2008

ABSTRACT

Transforming Teachers' Knowledge and Skills: Lesson Study in Mathematics Instruction for Diverse Learners at Middle Level

by

Vessela Ilieva, Doctor of Philosophy

Utah State University, 2008

Major Professor: Dr. Jim Barta
Department: Elementary Education

This study investigated the learning of middle school mathematics teachers as they worked in a student-sensitive lesson study group. Three mathematics teachers collaborated to develop and teach student-sensitive math lessons. The original Japanese lesson study model was extended to involve a diversity consultant with experience and expertise in providing student-sensitive instruction. Collaboratively, the members of the lesson study group tailored their mathematics lessons to provide enhanced mathematics instruction to the diverse groups of students in their classrooms. The lesson study team held weekly meetings to develop three student-sensitive lessons over a six-month period.

A case study design was used to allow an in-depth examination of teachers' participation in the student-sensitive lesson study, with the researcher being the tool of investigation. Data were collected from observations, interviews, and group-produced documents. The findings of the study indicate that the student-sensitive lesson study

stimulated in-depth mathematical discussions among participants and prompted a re-evaluation of the teachers' own mathematical knowledge. While in collaboration with the diversity consultant, the teachers worked to include student-sensitive context in mathematics lessons, and considered the critical role of high student expectations as part of student-sensitive mathematics teaching. The group engaged in reflection on their participation in student-sensitive lesson study, and they further considered factors that affected their knowledge and practice of improved mathematics teaching.

(257 pages)

ACKNOWLEDGMENTS

My words cannot express how thankful I am to my family. I had the best team of responsible and caring people to support and motivate me. You made it all worthwhile and possible.

I am also profoundly grateful to my committee chair, Dr. Jim Barta, for his continuous and invaluable mentoring, guidance, trust, and encouragement. My sincere thanks are extended to the other committee members: Dr. Jim Cangelosi, Dr. Gary Carlston, Dr. Jim Dorward, and Dr. Sherry Marx. Your help and advice were of highest value.

My work could not have been completed without the dedication of the teachers that took part in this study. They were tireless and patient with my many questions and inquiries. They were also a true inspiration, and I am thankful for their professionalism and friendship.

I am indebted to all professors and other faculty members for their quality instruction and high standards. I am thankful for having the best fellows throughout my studies. Thank you.

Vessela Ilieva

CONTENTS

Page

Page

Page

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Teacher professional development is increasingly necessary due to the growing demands of educational accountability. Professional development provides an opportunity to develop new instructional skills, enhance learning of new teaching practices, and reflect on one's own teaching (Elmore, 1996; Loucks-Horsley & Matsumoto, 1999). Educators who persistently work on implementing effective teaching practices and professional improvement in their classrooms are the driving force behind school change and educational growth in the ongoing standard-based reform (Darling-Hammond & McLaughlin, 1996; Glickman, Gordon, & Ross-Gordon, 2007; Gordon, 2004; Loucks-Horsley, Love, Stiles, Mundry, & Hewson, 2003; No Child Left Behind [NCLB], 2001; Ray-Taylor, Baskerville, Bruder, Bennett, & Schulte, 2006).

Effective, ongoing professional development is critical for the quality mathematics education of children; however, a number of widely used professional development initiatives do not engage teachers as contributors to, and disseminators of, professional knowledge. The success of any professional development initiative is questionable if teachers do not internalize its content or find value in transferring it to their practice (Glickman et al., 2007; Loucks-Horsley & Matsumoto, 1999; Urbansky & O'Connell, 2003). The development and implementation of effective professional learning opportunities for mathematics teachers is a major challenge for our educational system (Akiba, LeTendre, & Scribner, 2007; Loucks-Horsley et al., 2003).

The achievement gap in mathematics is a phenomenon observed and documented

in schools across the United States. The National Council of Teachers of Mathematics (NCTM, 2004) defined this gap as "an indicator of disparities between groups of students usually identified (accurately or not) by racial, ethnic, linguistic, or socioeconomic class with regard to a variety of measures (attrition and enrollment rates, drug use, health, alienation from school and society, attitudes toward mathematics), as well as test scores" (p. 2). Recognizing the continuous increase of students from diverse groups (Leonard, 2008), and the persistence of the achievement gap in mathematics for many of these students (Harris & Herrington, 2006), the NCTM suggested teacher professional development as one solution.

Researchers have started exploring the cultural relevance of mathematics instruction as one approach to minimization and elimination (Brenner, 1998; Lipka & Adams, 2004; Lipka et al., 2005a; Lipka, Sharp, & Brenner, 2005b). These studies build on the principles of culturally relevant pedagogy (Ladson-Billings, 1995a, 1995b) and culturally responsive teaching (Gay, 2000), and provide one possible direction for adding cultural emphasis to the professional development of mathematics teachers. Although some available research emphasizes the role of teachers in incorporating the cultural components of mathematics instruction, there is significant need for further exploration and analysis of how culturally responsive professional development can be used for the same purpose.

Problem Statement

Lesson study is a Japanese form of teacher-centered, classroom-based

professional development that is gaining popularity in the United States (Fernandez, 2002; Fernandez, Cannon, & Chokshi, 2003; Lewis, 2002; Stepanek, Appel, Leong, Mangan, & Mitchell, 2007; Wiburg & Brown, 2007). It has been implemented with mathematics teachers in both Japan and the U.S. (Fernandez, 2005; Isoda, Stephens, Ohara, & Miyakawa, 2007; Puchner & Taylor, 2006; Taylor, Anderson, Meyer, Wagner, & West, 2005). Major factors of research into mathematics lesson study in American schools are the rapid growth of diverse students' population (Leonard, 2008) and the related continuing achievement gap. Mathematics teachers in the U.S. today are predominantly White, monolingual, trained in practicing Euro-centered teaching approaches rooted in assumptions of domination of Europe-centered thought, and discovery in mathematics (Brand, Glasson, & Green, 2006; Joseph, 1997). The discrepancy between student diversity and teacher homogeneity may present a confounding factor when examining the effectiveness of lesson study as a model of professional development. Thus, a mirror image of the Japanese tradition in lesson study might not lead to similar positive results in the U.S. (Chokshi & Fernandez, 2004; Loucks-Horsley et al., 2003; Stepanek et al).

The research of lesson study that considers the cultural diversity of the student population, however, is quite limited (Wiburg & Brown, 2007). Wiburg and Brown studied teacher involvement in a bilingual lesson study, and reported that it led to increased student understanding of mathematical content. Given the fact that few other lesson studies for mathematical instruction are available, there exists an obvious need for expanding research on the topic. This study explores lesson study as a collaborative,

teacher-driven professional development model that includes a strong focus on culturally responsive mathematics instruction for the culturally diverse groups in the classroom.

Purpose of the Study

The purpose of this investigation is to explore how teachers' participation in culturally relevant lesson study influences their learning, mathematics teaching, and classroom practices as they plan and teach lessons with the support of a cultural consultant. The focus is on three guiding questions.

1. How does culturally relevant lesson study affect teachers' learning about mathematics instruction for culturally diverse student groups?
2. How does teachers' participation in culturally relevant lesson study influence their attitudes toward planning and delivering culturally relevant mathematics lessons?
3. What factors affect teacher's participation in and learning from culturally relevant lesson planning and delivery?

Delimitations

The focus of this study is on the process of culturally relevant mathematics lesson planning with support from a cultural consultant, and the teachers' reactions to their participation in this type of lesson study supported by personal accounts of the relevant learning and practice. Student achievement is not explored and teachers' past classroom and instructional practices that are unrelated to culturally responsive instruction are not analyzed unless teachers use them to compare and contrast previous and current instructional techniques. Teachers' previous professional training is also not evaluated

unless teachers discuss these as relevant to their experiences with this culturally relevant lesson study.

Definitions of Terms

There are terms that need additional clarification so that those reading this share the same understanding of their uses. These terms are culture, ethnic group and ethnicity, culturally relevant teaching, culturally responsive teaching, lesson, and Latina/Latino/ Hispanic.

Culture has numerous definitions found in literature. Malloy and Malloy (1998) define it as "shared meaning, but not necessarily consensus–the taken-for-granted values and beliefs that are seen in what people do, what they know, and the tools they use" (p. 245). Ascher's (1991) definition offered a similar understanding of culture but adds some components: "in any culture people share a language, a place, traditions, and ways of organizing, conceptualizing, and giving meaning to their physical and social world" (p. 2). Banks (2001) suggested six components of culture: first, values and behavioral styles; second, languages and dialects; third, nonverbal communications; fourth, cultural cognitiveness (which sets apart cultures); fifth, perspectives and frames of reference; and sixth, identification. In this study, culture was defined as the shared set of verbally or nonverbally communicated traditions and beliefs developed and maintained by those sharing a language, an environment, a place, a frame of reference, and tools for creating meaning of their world.

Ethnic group is "a microcultural group with several distinguishing characteristics" (Banks, 2001, p. 78). Although there is no strict agreement among social scientists on the

characteristics that define an ethnic group, Banks included “ancestry, culture, history, traditions, and sense of peoplehood” (p. 78). He defined ethnicity as “the individual’s psychological identification with his or her ethnic group.” However, for the purposes of official data collecting and reporting in the United States, ethnic group membership appears to be established on broader ground than Banks’ ethnic group membership: “as the heritage, nationality group, lineage, or country of birth of the person or the person’s parents or ancestors before their arrival in the United States (U.S. Census, 2000a). Since cultural group membership deals with more immediate practices and beliefs created and recreated by members of the group than does the ethnic group membership defined by the U.S Census, in this study, the relevance of mathematics lessons to students will be sought using cultural group membership as reference.

Culturally relevant teaching was defined by Ladson-Billings (1994) as teaching that “empowers students intellectually, socially, emotionally, and politically by using cultural referents to impart knowledge, skills, and attitudes” (p. 17). She added, “Culturally relevant teaching uses students’ culture in order to maintain it.” In this study, culturally relevant teaching was defined as that which integrates school experiences with students’ home cultural practices as a vehicle for the learning of mathematics.

Culturally responsive teaching was defined by Gay (2000) as a paradigm that is concerned with the “performance of underachieving students from various ethnic backgrounds—one that teaches *to and through* their personal and cultural strengths, their intellectual capabilities, and their prior accomplishments” (p. 24). According to Gay, culturally responsive teaching is validating, multidimensional, and transformative, and

includes “cultural knowledge, prior experiences, frames of reference, and performance styles of ethnically diverse students to make learning encounters more relevant and effective for them” (p. 29). Gay suggested that “culturally responsive” and “culturally relevant” are labels of identical efforts to provide “instruction more consistent with the cultural orientations of ethnically diverse students” (p. 29). In this study, “culturally responsive” and “culturally relevant” were also used interchangeably.

Lesson in the lesson study tradition was defined as one instructional period planned for and delivered within a set time and completed that day. However, this lesson is not an isolated piece; it may fit within the flow of a series of planned instructions or could be a part of a series of lessons (Wiburg & Brown, 2007). For the purpose of this research, a lesson was the instruction planned and taught for the duration of one class period at the participating school, which was about 45 minutes in length.

Latina/Latino and Hispanic was used interchangeably on many occasions and there is a lack of consensus on their appropriate and preferred usage. While Hispanic was the term adopted by the government and was the one used in documents and publications quoted in this study, Latina/o was the one preferred by those who reject the connectedness with Spain suggested by the term “Hispanic” (G. Huerta, personal communication, October 7, 2007). Since both terms were widely used in both literature and popular discourse, and to preserve the authenticity of terminology used by cited sources, this study used the more summative term of Hispanic/Latino adopted by some scholars (for example, Smith-Adcock, Daniels, Lee, Villalba, & Indelicatto, 2006).

Hispanic/Latino students were considered members of the large ethnic group of

Hispanics officially defined and reported by the U.S. government. The research did not refer to ethnicity as "a social psychological sense of peoplehood in which members of a group share a unique social and cultural heritage that is transmitted from one generation to another" (Hall & Barongan, 2002, p. 17). When a reference to ethnicity is made in the research, it will be only to refer to the ethnic category of Hispanic/Latino established by U.S. Census.

According to the U.S. Census, Hispanics/Latinos can be of any race: "People of Hispanic origin may be of any race and should answer the question on race by marking one or more race categories shown on the questionnaire, including White, Black or African American, American Indian or Alaska Native, Asian, Native Hawaiian or Other Pacific Islander, and Some Other Race" (U.S. Census, 2000b). In this research, the Hispanic/Latino student was identified by their ethnic group membership. If any reference was made to the race of the Hispanic/Latino students, this research took into account the possibility that the race of the Hispanic/Latino students could also be White.

Assumptions

An assumption of this study was that the teacher participants were all competent in mathematical content knowledge and general instructional methods, but not experienced in considering the role culture plays in the teaching and learning of mathematics. They were competent in individually creating lessons but not experienced in collaborative lesson planning or using self-evaluative techniques to improve their own teaching and lesson planning. Another assumption was that the teachers were truthful in their responses to the interview questions and in any other conversations with the

researcher and the other lesson study group members.

Summary

The culturally relevant lesson study model explored in this study responded to the need for effective professional development that takes into account the needs of teachers and students. The study investigated the learning of teachers working collaboratively to create and deliver mathematics lessons that consider the cultural diversity among the students in their classrooms. This study contributed to the literature on culturally relevant professional development, to its practice, and to the perspectives of its future applications.

CHAPTER II

REVIEW OF THE LITERATURE

This literature review includes the theoretical perspectives that frame the study and provides a lens for the exploration and focus on professional development. An overview of sociocultural theory, adult learning theories, culturally responsive teaching, and the discipline of noticing is included. The second section of the literature review includes existing research on professional development using teachers' perspectives on instructional or pedagogical effectiveness as a point of reference. Finally, lesson study is discussed as a specific model for effective professional development. Since the research focuses on applications of lesson study with mathematics teachers of students from various cultural backgrounds, the literature review concludes with culturally relevant mathematics professional development and sensitive mathematics instruction.

Sociocultural Theory

After Charles Darwin's *The Origin of Species* was published in 1859, the dominating metaphysical paradigmatic belief that truth exists outside and independently of humans was challenged by intersubjective discourses. These discourses situated knowledge construction in a social environment, under the conditioning of human relations and interaction (Davis, 2004). Many rejected the belief that humans create truth in a search for the ideal; scholars claimed that humans discover truth through a process that was evolutionary in nature.

As part of intersubjectivist tradition, the constructivist theory of learning maintains that "learners actively construct their own ("internal," some would say) sets of meaning or understanding. Knowledge is not a mere *copy* of the external world, nor is knowledge acquired by passive absorption or by simple transference from one person (a teacher) to another (a learner or knower). In other words, "Knowledge is *made*, not *acquired*." (Phillips, 2000, p. 7). A leading notion of the constructivist learning theory, therefore, is the ability of individuals to construct their own understanding of reality by building on their existing knowledge, attitudes, and interests (Howe & Berv, 2000). The role of the learner within this perspective allows for individual perspectives to shape one's reality.

Within the constructivist framework, the work of a prominent Russian/Soviet psychologist, Lev Vygotsky, led to the formulation of foundational premises of the sociocultural theory of human development. His work was influenced by Darwinian thought, but was also shaped by ideas from Karl Marx and Friedrich Engels. Marx and Engels speculated that people developed their own history by participating in socially shared activities with other individuals while using tools to mediate them (Axel, 1997; Luria, 1979). Vygotsky's ideas evolved in the early 20th century and were thus strongly influenced by events following the Socialist Revolution and the subsequent changes in the newly organized Soviet Union. Researchers distinguish different periods in Vygotsky's work, from a predominantly philosophical focus in his early work to more practice-oriented work on child development in his later years. Vygotsky's work was introduced in the United States in the 1960s, and became influential with American

scholars that edited his work such as Michael Cole and Sylvia Scribner (Vygotsky, 1978) as well as Rogoff (2003) and Wertsch (1985).

Sociocultural theorists claim that there is no prevalent influence of either biological or environmental factors on human development. They attribute learning to interaction between these two sets of variables in the realm of cultural exchange (Cole & Cole, 2001). However, from a sociocultural viewpoint, the efforts of the learner to make sense of the environment are an integral part of this dynamic process. As Gauvian (2005) stated, “From a sociocultural perspective, cognitive development is the process by which the child’s emerging maturational capabilities interact with the cultural context of development as it is instantiated in social experience” (p. 12). Language, traditions, artifacts, beliefs, and other components of culture reflect in biological and environmental changes and in adaptation that affects the development of the generation. From this broad cultural level, the changes are internalized slowly through a mutual participation of children and adults in a process of meaningful construction.

Cole and Cole (2001) summarize this process of continuous developmental exchange by coining the term bio-social-behavioral shift in reference to “major transition points in development during which a convergence of biological, social, and behavioral changes gives rise to distinctively new forms of behavior” (p. 38). In her definition on this phenomenon, Rogoff (2003) stressed another tacit belief of cultural theorists: that culture not only influences human development, but at the same time, humans influence culture by participating in it.

Vygotsky's contributions to the theories of human development continue to be analyzed and discussed today (Kozulin, Gindis, Ageyev, & Miller, 2003). Sociocultural scholars have also focused on the application and development of Vygotsky's ideas with respect to learning and schooling. Several key concepts scaffold these efforts and, being central to the theoretical framework of this research, are further discussed.

Mediation and Internalization

The concept of mediation rests at the heart of Vygotsky's sociocultural theory. Vygotsky argued that humans use physical or psychological tools to interact with the world and these tools are culturally specific mediators of this interaction. Establishing relationships with other humans is also mediated through culturally specific artifacts, and many of them are symbolic in nature. These may include, for example, language, numbers, music, and art. Contact with mediators can be direct or indirect, and humans can establish mediated relationships with previous generations and their tools. Tools of mediation can also be modified to fit the needs of the learner. While in the process of mediation, language is considered the "tool of tools" that is intellectually stimulating only if applied in social context (Cole, 1996, p. 108).

Private speech is another mediator related to language and is used when engaging in self-communication to guide one's thinking process (Appel & Lantolf, 1994, as cited in Fushino, 2004; Lantolf, 2000). It is closely related and conditioned by another key concept of the sociocultural theory, which is the concept of internalization of socially constructed knowledge or "the process through which higher forms of mentation come to be" (Lantolf, p. 13). These reflect the concept of "internally situated" mediation (Lantolf,

p. 14), and through internalization, private speech can become internal speech. In all mediated relationships, the Vygotskian perspective rejects any mechanical nature of transfer. Emphasis is placed on the mediated nature of the human mind, which develops through mediation with other people and with the environment (Cole, 1996; Daniels, 2001; Lantolf).

In this research, participants engaged in mediation in several ways. First, they were engaged in professional development conversations and continuously mediated ideas through language. Second, the teacher participants could use private speech when proposing their own ideas to their peers or when talking through a problem. In addition, they internalized their private speech when working privately on the lessons they discussed and developed. Other possible mediation was the use of different tools to communicate within the lesson study group or with students. These tools could include manipulatives, real-world objects, published material, or worksheets.

Apprenticeship

Sociocultural theorists distinguish between four time frames that occur in the cultural conditioning of development. They include (a) individual learning of the moment, (b) individual learning throughout one's lifespan, (c) historically determined learning of the community, and (d) development of the species (Scribner, 1985; Wertsch, 1985).

These four levels may be viewed as layers that constantly interact to provide cultural conditioning for the learning opportunities of people. There is a constant exchange of information between all the layers, and this leads to continuous addition of

new information to each layer. Sociocultural theorists situate human development within the environment of historically and culturally predetermined traditions and values imbedded in the actions of the caregivers. Through these actions, humans not only support but also modify and transform the cultural practices while passing them on to new generations.

Within these processes of learning and teaching culturally conditioned practices, all children are seen as "quintessential cultural apprentices who seek the guided participation of their elders" (Adamson & Chance, 1998, p. 21; Rogoff, 1990). The notion of apprenticeship reflects the dynamic nature of culturally conditioned interaction and emphasizes the culturally determined relationships between generations. It also includes the tools used within the culture and their specific culturally dependent applications. The understanding of apprenticeship also allows for observations of a reciprocal relation between teachers and learners (Lave, 1988; Maynard & Martini, 2005; Rogoff, 2003). Sociocultural theory supports a collaborative model for learning that considers higher-level thinking as a result of social interaction of apprenticeship in a culturally specific environment where socially and culturally engaged participants also influence the social processes (Renshaw, 1992).

In this research, social interaction between teacher participants was also a form of professional apprenticeship. The teachers collaborated to learn from each other and from their various experiences in the classroom. The apprenticeship was demonstrated through communication and anticipated learning from the cultural advisor and was also found during classroom observations of a lesson planned by all the teachers (but taught by just

one). The teachers took notes of these observations and then shared them. They engaged in apprenticeship while learning from each as they discussed the lesson and its teaching.

The social nature of learning is central to the analyses of Sociocultural theorists, with a focus on the environment, its cultural content, and its relevance to imitation as a way of learning in social context. It is closely related to the collaborative nature of learning mentioned earlier. Vygotsky claimed that in order to develop, the human mind needs to function in a social environment and "every function in the child's cultural development appears twice: first, on a social level, and later, on the individual level" (Vygotsky, 1978, p. 57). Social learning, according to Vygotsky, needs to happen within the child's zone of proximal development (ZPD). This concept suggests that children need stimulation beyond their current level of performance and comfort so that actual learning can take place (Fushino, 2004; Lantolf, 2000; Rogoff, 2003). In terms of teaching, the ZPD is seen as the zone where teacher-student interactions lead to learning, just as the expert leads the novice beyond where the novice could go without assistance (Newman, Griffin, & Cole, 1989). This interaction is culturally conditioned through appropriation. Alexei Leontiev, a student of Vygotsky, suggested that "the child's appropriation of culturally devised 'tools' comes about through involvement in culturally organized activities in which the tool plays a role" (Newman, Griffin, & Cole, 1989, p. 63). Some researchers called for extending this appropriation beyond the expert/learner dyad within the ZPD. Lantolf suggested, "ZPD then is more appropriately conceived of as the collaborative construction of opportunities for individuals to develop their mental abilities" (p. 17).

Within the concepts of social learning and the ZPD, Rogoff (2003) introduced the concept of guided participation as central to learning. In guided participation, teachers and learners engage in a mutual structuring of participation and bridging of meaning. Apprenticeship also plays a big role in these collaborative processes of sharing (on the side of the teacher) and meaning construction (on the side of the learner). Rogoff argued that the Vygotskian concept of the ZPD is more restrictive than guided participation and situates the ZPD as mostly relevant to formal education because it suggests instruction with certain direction. The concept of guided participation broadens the definition of the learning process to an activity that might occur in a social environment even without initial intention for learning.

In this research, the lesson study professional development model is an inherently social type of learning environment. The teachers were engaged continuously throughout the project in a social interaction, and were focused on their professional growth, effectiveness, and progress. The study involved guided participation as the cultural consultant and the lesson study team provided guidance for the fellow teachers.

Sociocultural Theory and Professional Development

Proponents of the sociocultural theory view learning as a process of enculturation when learners engage in interaction with teachers, other learners, and artifacts through mediation. Teachers provide guidance through modeling and mentoring, and teaching is described as orchestrating the process of internalization of the social practices of the community (Davis, 2004). Kozulin (2003) emphasized the importance of the human

mediators–the teachers–for the learning process. In support, Merriam and Cafarella (1991) suggested, “Adult learning in the most formal settings occurs under the directions of an educator or trainer who takes on the role of mediating the ways in which people approach their training” (p. 28). This type of learning is observed when teachers are engaged in a professional development activity. Adult learning, however, is not limited to formal training and its sociocultural nature is rooted in the process of socialization, with the learner taking in “the knowledge, values, beliefs, and attitudes of the society in which they live” (Jarvis, as cited in Merriam & Cafarella, p. 115). Several adult learning theories, relevant to the professional development of inservice teachers, support the sociocultural nature of adult learning.

Adult Learning Theories

Planning for effective professional development requires alignment of the professional development formats and approaches with the theories of adult learning (Glickman et al., 2007; Gordon, 2004; Loucks-Horsley et al., 2003). In describing the complexity of adult learning, Merriam and Cafarella (1991) claimed, “Understanding learning in adulthood is like piecing together a puzzle–there are many parts that must be fitted together before a total picture emerges” (p. 121). The individual learner, the context for learning, and the learning process are three major clues that help us solve this puzzle. However, as Merriam and Cafarella suggested, “a phenomenon as complex as adult learning will probably never be adequately explained by a single theory” (p. 264). In this review, andragogy, adult learning in social context, and situated cognition are included as

models that illustrate adult learning theories in sociocultural context. These theories encompass the complexity of adult learning through models that complement and support Vygotsky's sociocultural theory and support the need for practice-oriented models for planning and implementation of professional development.

Andragogy

Andragogy is a learner-centered theoretical model for adult learning developed by Knowles (Merriam & Cafarella, 1991). It is built on five main assumptions: (a) adult learners are in charge of their learning, (b) they use their accumulated life experiences to scaffold their learning, (c) there is a close relationship between their learning and their social roles, (d) adults engage in problemsolving that has immediate applications, and (e) they are intrinsically motivated for learning (Merriam, 2001b). These assumptions suggest that andragogy supports the personal characteristics of the learner. While some of its main assumptions have been critiqued for their broadness (for example, there are adult learners who are not self-motivated), it has strongly influenced the development of other adult learning theories by positioning the learner as a partner in the learning process rather than just a receptor of the instructor's knowledge. However, it assumes that instructors are in charge of the orchestration and facilitation of the learning process, and that the role of these instructors to direct and organize learning activities is significant (Merriam & Cafarella). Some scholars believe that "andragogy remains as the most learner-centered of all patterns of adult educational programming" (Houle 1996, as cited in Merriam, p. 6).

The lesson study model is a voluntary professional development activity. It illustrates that motivation is an integral part of teachers' learning. The teachers involved in the project are in charge of their learning and use their accumulated life experiences to scaffold it. In being involved in professional development in their immediate area of expertise–mathematics–there exists a close relationship between teachers' learning and their social roles as educators. In lesson study, the participants work on instruction improvement and immediately apply their planned lesson in their classrooms. The adult learners engage in solving the problems on culturally relevant instruction that has immediate applications.

Adult Learning in Social Context

Peter Jarvis developed a theory of adult learning that focuses on the process of learning rather than on the characteristics of the learner (Jarvis, 1987). The theory situates adult learning in the world that surrounds the learner and reflects on the reciprocal relationship between learners and their social context. Jarvis suggests that learning happens when there are situations that adults are not able to handle with their existing knowledge, or as Jarvis describes it, a discrepancy existing between biography and experience (Merriam & Cafarella, 1991). This discrepancy appears similar to the concept of the zone of proximal development defined by Vygotsky. Jarvis explained that learning occurs through socially meaningful situations and is interaction-based with language having a central role in the process. There is significant overlap with the premises of the sociocultural theory. Although Jarvis' model is credited for its thoroughness in explaining different types of adult learning processes and outcomes, it is also critiqued

for being too broad and not making clear the distinctions between theories of learning involving children and adults (Merriam & Cafarella).

The social context of learning within the lesson study model and the discrepancy between teachers' expertise in mathematics and their training and knowledge about culturally responsive teaching reflect the interaction suggested by Jarvis. Teachers' learning should be viewed on a broader platform than just participants' individual characteristics. Rather, environmental influences help shape the learning process. In this study, adult learning will be considered an activity that blends ideas from andragogy and social context of adult learning.

Situated Cognition

Situated cognition is one model of adult learning that is representative of the context-based adult learning framework. In situated cognition, learning happens while immersed in specific experiences with a group of other adult learners. "From a situated view, people learn as they participate and become intimately involved with a community or culture of learning, interacting with the community and learning to understand and participate in its history, assumptions, and cultural values and rules" (Hansman, 2001, p. 46; Lave & Wenger, 1991). The notion of context-based learning is also rooted in the sociocultural framework, but with an emphasis on the specifics of adult learning. It is based on the notion that "learning in context is paying attention to the interaction and intersection among people, tools, and context within a learning situation" (Hansman, p. 44). According to Hansman, it also is "incorporating the learners' developmental needs, ideas, and cultural context into the learning experience" (p. 44).

Two specific conceptual models embody the ideas of situated learning: communities of practice and cognitive apprenticeship. Both are sociocultural in nature and situate the learner in a collaborative environment. Three principles intertwine within the communities of practice model: mutual engagement, joint enterprise, and shared repertoire (Wenger, 1998, as cited in Hansman, 2001). Members of the communities of practice are in charge of their learning as well as the group's organization, and the emphasis is on conscious self-identification with the group and commitment to its goals and expert work. The model considers the role of the learner within the group, rather than the actual learning processes that participants engage in. The collaborative nature of the lesson study, the common instructional goal shared by all group members, and the joint efforts to develop a lesson that supports the achievement of this goal suggest that lesson study is a form of a community of practice.

In contrast, the cognitive apprenticeship model does not focus as implicitly on social components in terms of organization and responsibility of participants. Rather, its emphasis is on the learning process and its particular steps of modeling, approximating, scaffolding, fading, self-directed learning, and generalization. However, theorists of the model emphasize that "Those interested in an apprenticeship approach, or more generally in theories of learning-in-practice, assume that processes of learning and understanding are socially and culturally constituted, and that what is to be learned is integrally implicated in the forms in which it is appropriated" (Lave, 1997, p. 18).

The situated cognition framework focuses on opportunities for adults to share expertise and experience while learning. Similar to dimensions of situated cognition, the

communities of practice and cognitive apprenticeship models emphasize different strands of the complex process of adult learning, allowing researchers to consider different perspectives when working with adults. As a multifaceted model for teacher learning that channels current knowledge and experience toward achieving mutual goals directed to student progress, the use of lesson study incorporates elements of both theoretical frameworks in order to provide maximum benefits for its participants. The research and practice of both communities of practice and cognitive apprenticeship will inform this study.

The outlined adult learning theories and models are situated within Vygotsky's sociocultural theory as a vehicle for creating adult-appropriate learning experiences that involve adults through their existing knowledge, life experiences, and existing goals. In each, adults are considered participants in social situations within a cultural context. Whether participating in communities of practice or cognitive apprenticeship, teachers are presented with opportunities to engage in professional learning. They search to improve their teaching and provide better instruction to their students. The sociocultural core of teacher learning transfers to the classroom where the students' learning is also sociocultural in nature. Jarvis (2004) described the conflict between schools as institutions of formal learning and this sociocultural nature when he claimed the following:

> Learning was considered to be restricted to the formal educational institutions, although sociologists have always recognized that socialization into the culture of a society or organizational sub-culture has always occurred to a great extent through learning in non-formal and informal social situations. (p. 30)

To create and support connections between students' experiences and the learning they engage in while in socially and culturally different environments, teachers need to teach, or mediate learning, in a way that reflects the sociocultural nature of teaching and learning. Establishing relationships among teaching, learning, and the environment is critical for the learning outcomes of diverse student populations (Gay, 2000; Ladson-Billings, 1994). Teachers can gain skills and knowledge in creating these connections by participating in professional development that considers the principles of culturally responsive teaching and cultural mediation of instruction.

Culturally Responsive Teaching

The sociocultural nature of teaching and learning in a multicultural society is a call for teachers to take on the unique role of cultural broker in the classroom (Gentemann & Whitehead, 1983). Diamond and Moore (1995) described this role as the blending of three components: (a) of a cultural mediator, (b) cultural organizer, and (c) cultural orchestrator of the learning process. As cultural mediators, teachers provide opportunities for students to express their cultural backgrounds and bring them into the learning process. As cultural organizers, they work against prejudice and stereotyping in the classroom and model respect for different cultures. As cultural orchestrators, teachers create meaningful instructional opportunities and "help students translate their cultural competencies into learning resources" (Gay, 2000, p. 43).

Gay (2000) argued that teachers who consciously include these components in their practice subscribe to a new pedagogical paradigm of teaching–the paradigm of

culturally responsive teaching. The basic premise of culturally responsive pedagogy is that it blends experiences and traditions from the native cultures of the students in the classroom. “It uses ways of knowing, understanding, and representing various ethnic and cultural groups in teaching academic subjects, processes, and skills” (Gay, p. 43).

Hollins (1996) argued that teachers’ classroom behaviors with respect to culture can be described as one of three types. Type I includes teachers who view and treat culture in the classroom as a static artifact and behavior. The social context of learning in their classroom is teacher directed, and any efforts to support the learning needs of culturally diverse groups of students are restricted to remediation and mainstreaming of the learner. Type II teachers’ behaviors include those that view culture as a social and political relationship. Hollins claimed that teachers displaying this type of behavior do recognize the uniqueness of their learners’ cultures but still feel uncomfortable redesigning their instruction to address this uniqueness. However, they do include multicultural activities and themes from history as supplementary pieces that they hope address issues of diversity and its effects on learning.

Teachers who display behaviors of Type III, according to Hollins (1996), “strive to make linkages between the home-culture and school learning for students from different cultural and ethnic backgrounds” (p. 8). They do this by using instructional approaches that recognize and use students’ knowledge and experience gained as members of a cultural group. There is little disconnect or inconsistency between what is learned in and outside of school. The social contexts of learning at school and at home do not conflict with each other. Hollins argued for a theory of culturally mediated

instruction, which builds on the instructional approaches of Type III teachers and is also "characterized by the use of *culturally mediated cognition, culturally appropriate social situations for learning*, and *culturally valued knowledge in curriculum content"* (p. 138-139). In this definition, "culturally mediated cognition in instruction refers to approaches using the ways of knowing, understanding, representing, and expressing typically employed in a particular culture" (p. 139). This cultural mediation aligns with the premises of culturally responsive teaching defined by Gay (2000).

The culturally responsive teaching described by Gay (2000) and Hollins (1996) called for a transformation of practice. Approaches to this transformation include studying one's own practice, studying expert practice, building teacher support groups, participation in teacher professional development, and engagement in teacher study groups. One theoretical approach, that of discipline of noticing, supports these types of teacher engagements and examinations to help them become aware and observant of the principles of culturally relevant teaching.

Discipline of Noticing

Mason (2002) stated that "noticing is an act of attention, and as such is not something you can decide to do all of a sudden." With respect to teaching, noticing is a planned and purposeful activity that examines in-depth situations and practices, or as Mason called it, "intentional noticing." He defined noticing as "a collection of practices both for living in, and hence learning from, experience, and for informing future practice." Mason extended the discipline of noticing to the professional field, and

suggested that noticing could include systematic observations of other's practice, building awareness of elements in their ways of doing, and transferring some or all of the noticed elements in our own practice. The last stage is critical for making noticing an integral part of one's practice. As Mason stated, "the cornerstone of noticing as method of enquiry is trying things out for ourselves rather than taking them on trust as a result of some statistical study, logical argument, or authoritative assertion" (p. 30).

According to Mason (2002), noticing occurs when three interacting worlds intersect: "the word of personal experience; the world of one's colleagues' experience; and world of observations, accounts, and theories" (p. 93). The discipline of noticing supports a sociocultural approach to in-service professional development that considers teacher's ways of learning and allows for new perspectives such as the cultural responsiveness of teaching and learning to be incorporated. Mason said that noticing "is marked by a sudden shift in what is at the centre of attention," and that it "provides a way of supporting colleagues in their professional development as well as ways to work on one's own development" (p. 148). He promoted the discipline of noticing as an "action-oriented enquiry" (p. 149), and encouraged its applications in a research-type professional development. Mason suggested six building blocks that constitute the frame of noticing and its research focus and includes, "Keeping accounts; developing sensitivities; recognizing choices; preparing and noticing; labeling; and validating with others" (p. 61). The culturally responsive professional development of this study fits Mason's framework by providing all six opportunities for examination of practice

through noticing. In addition, the discipline of noticing engages teachers in activities that are in unison with the main features of effective professional development.

Effective Professional Development

Teacher professional development is at the core of the efforts for school improvement and increased student achievement in the era of educational accountability (Glickman et al., 2007; Gordon, 2004). There is a wide spectrum of theoretical models that describes effective professional development. Gordon argued that professional development is continuous throughout teachers' professional careers. According to his view, it is an ongoing process that starts as early as preservice education and practicum. It continues throughout the job application and hiring processes then extends throughout one's career as a teacher. This last inservice professional development piece constitutes the largest segment in Gordon's model, both in terms of duration and complexity. He suggested that training, collegial support, reflective inquiry, external support, and teacher leadership were five general frameworks for inservice professional development. Each framework is characterized by specific components. Still, these frameworks are not separate entities; they overlap and provide a comprehensive understanding of the organizational details of different types of professional development.

Gordon's professional development frameworks considered the specific needs for improvement within a school and matched them with resources and activities. Throughout the planning and implementation of a selected professional development approach, it is necessary to consider the needs of the teachers. Teachers are

professionally and personally invested in the process of professional development, and their input is critical for providing direction and meaning of planned initiatives and their outcomes. If professional development is to have an effect on teaching and consequently on student achievement and school improvement, it is crucial that it involves teacher buy-in and commitment to take the professional learning to the classroom (Gordon, 2004).

In their research, Garet, Porter, Desimone, Birman, and Yoon (2001) involved more than a thousand mathematics and science teachers nationwide in an inquiry about professional development features that affect teacher learning. They found that with respect to the structure of professional development, teachers considered the length and form of the activities as critical to their participation and engagement in a combination with opportunities for collective participation. Sustained professional development was preferred over short-term or one-time activities. Teachers also gave preference to what Garet and colleagues called reform-type forms of professional development, similar to coaching or participating in study groups. Teachers reasoned that these forms are closely related to in-class practice and could take place inside the classroom, in contrast with more traditional forms, like listening to a lecture. Teachers reported that they wanted to be part of professional development that is focused on content, has opportunities for active learning, and is related to other learning activities. Garet and colleagues concluded that the preference given to reform activities is grounded in their longer duration, which in turn allows for building collectively working communities of practice across grades or subject areas.

In an investigation of the effects of policy on mathematics and science teachers' decisions to participate in professional development, Desimone, Smith, and Phillips (2007) surveyed teachers about types of policies that contribute to participation and subsequently lead to teacher learning and improvement of practice. The researchers asked teachers to distinguish between authority as the degree to which a policy is persuasive for teachers; power (the rewards and sanctions of a policy); consistency (the alignment with other elements of a policy); and stability (of participants and ideas within a policy) as elements that contribute to their attitude toward professional development. The findings suggest that authority, or the persuasiveness of a policy, is the most influential attribute when compared to power, consistency, or stability. Desimone and colleagues further described that two measures of authority–teacher involvement in policy preparation and personal engagement in planning and presenting–are what teachers consider most beneficial for active participation in professional development. The researchers concluded that mathematics and science teachers were interested in professional development that required their active participation and was conducive to collaboration and interaction. These findings were consistent with teachers' willingness to participate in reform-type professional development activities (Garet et al., 2001).

Guskey (2003) also studied characteristics of effective professional development. He made similar conclusions about the critical influence of collaborative work and collegiality on teachers' perceptions regarding the effectiveness of professional development. In agreement with Garet's report, Guskey also suggested long-term duration as another important attribute of effective professional development.

In a study that involves elementary teachers, Carroll (2005) investigated their understanding of effective mathematics teaching as one way to plan for optimal professional development. Three themes arose from the analysis. The first was that "professional development is part of lifelong learning and involves the development of new mindsets and attitudes, the development of insights into experience, and the taking of personal responsibility for learning about teaching" (p. 206). Second, teachers favored the process of building and maintaining meaningful collegial relationships. Third, the existence of these relationships provided stimuli for ongoing reflection on one's practice. As with the previously cited studies, long-term professional development that allows for collaboration and personal involvement in reflexive learning was what teachers consider important in an effective professional development model.

In his analysis of effective teacher professional development, Ferguson (2006) suggested five challenges to organizing and sustaining initiatives that engage teachers (p. 48).

1. Introducing new activities in ways that inspire buy-in.
2. Balancing principal control with teacher autonomy.
3. Committing to ambitious goals.
4. Maintaining industriousness in pursuit of those goals.
5. Effectively harvesting and sustaining the gains.

Ferguson's summary showed that the features perceived by teachers as most effective for professional development also posed some of the biggest challenges for professional development implementation.

In their summary of the current state of professional development for teachers of science and mathematics, Loucks-Horsley and Matsumoto (1999) argued that often these challenges occur due to discrepancies between what is believed to be effective and what teachers actually find effective in professional development models. One recommended approach to addressing the challenges of implementing effective forms of professional development focused on teacher learning can be achieved through professional teacher collaboration over long periods of time supported by opportunities for direct applications of this learning into the classrooms (Loucks-Horlsey & Matsumto; Loucks-Horsley, Stiles, & Hewson, 1996). Lesson study is one form of professional development that incorporates these characteristics.

Lesson Study

Kounaikenshuu is a Japanese model for teacher professional development. In its country of origin, it is used in schools nationwide and is valued as a "diverse set of activities that together constitute a comprehensive process of school improvement" (Stigler & Hiebert, 1999, p. 110). While the model includes a set of different activities that engage schoolteachers and personnel on different levels, its most popular component is lesson study (*jugyou kenkyuu*). Lesson study engages teachers in a long-term collaboration. Researchers report that lesson study is built on the notion that improvement of teaching practice should be addressed in the authentic environment of the classroom. As Stigler and Hiebert stated, "If you start with lessons, the problem of how to apply research findings in the classroom disappears" (p. 111).

The typical lesson study starts by defining a problem that originates in the classroom. A group of teachers who share similar concerns about their students or instruction come together and discuss what steps they can take to solve the problem. They establish the problem in terms of classroom practice, decide on a specific lesson, and focus on the problem and its solution. If there are many teachers who share similar concerns, they usually break up into groups of four to six, according to grade level or content taught. Each group then engages in lesson planning. Group members work collaboratively to address the initially defined concern. Teachers rely on their own expertise, the literature, and available research to provide a rationale for their lesson improvement suggestion. In addition, a lesson study group often invites a knowledgeable other (also called an outside expert or outside advisor), a person who contributes knowledge in an area where the participants might need extra assistance and support. The goal of the lesson planning process is not to craft a perfect lesson, but to tailor the lesson and the ongoing teacher discussions to address the initial concern and align it with the long-term or immediate needs of the students as initially identified by the teachers.

When the lesson plan is complete, the team decides on one member who will teach the lesson to her or his class, while the other team members observe and take detailed notes. The teachers might also videotape the lesson and use the material in the discussion and analysis session that follows. The discussion of what was observed in the classroom often leads to lesson revisions that take into account the notes of all team members. If the teachers decide that significant changes are needed, they choose another team member to teach the new version of the lesson to her or his class, while the rest

again observe. A debriefing session completes one lesson study cycle. Often, the teachers summarize their experience in a concluding report with suggested improvements. Then the team is ready to start another cycle that incorporates the suggested changes and a new lesson is planned. An outline of the cyclical lesson study process based on the work of Lewis (2002) is presented in Figure 1.

Lesson Study as an Effective Professional Development

Lesson study gained popularity in the United States' educational community after James Stiegler and James Hiebert published "The Teaching Gap" in 1999. The authors compared the mathematics teaching practices in Germany, Japan, and the United States as part of the Third International Mathematics and Science Study (TIMSS). Since then,

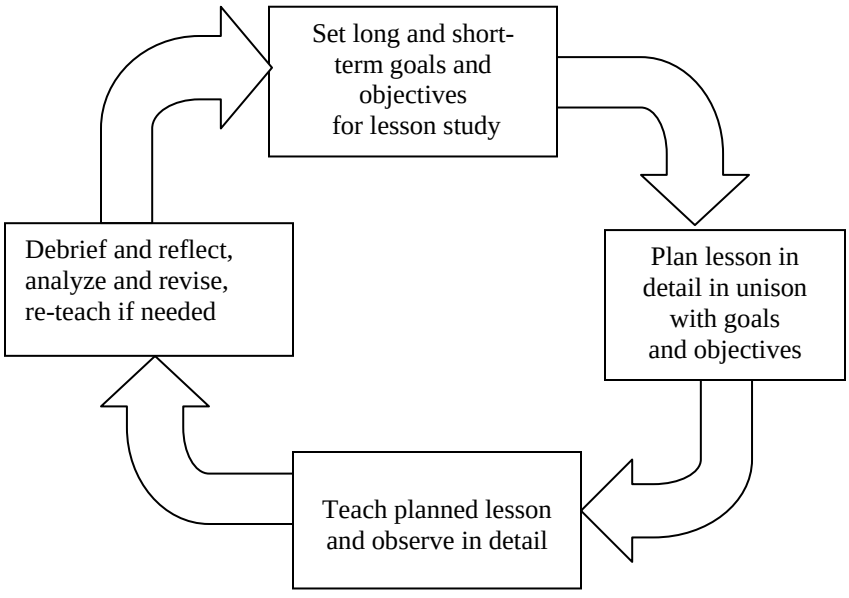

Figure 1. The lesson study process.

lesson study has been applied as a professional development model in different parts of North America, and researchers have reported a spectrum of results relevant to lesson study applications.

Lesson study fits the effective professional development framework outlined earlier. It is a long-term professional development model focused on continuous improvement. It is centered on specific classroom concerns, and the effects from addressing these concerns are immediately observed again in the classroom. It is also a process that requires continuous and active collaboration where teachers are directly contributing to professional development as well as to the larger body of knowledge about effective instruction. Lesson study also fits within the sociocultural theoretical framework for teaching and learning and the notions of the mediated nature of learning through apprenticeship in social context. Although lesson study has become popular in the United States only in the last decade, these theory-driven claims that lesson study is an effective form of professional development have already received some empirical support.

Puchner and Taylor (2006) described elementary teachers' satisfaction and increased efficacy after participating in a mathematics lesson study. The teachers at one of the two participating schools reported buy-in and success, which they attributed to their collaborative work. At the same time, a group of elementary teachers at the other participating school encountered many challenges due to personal and interpersonal reasons. These experiences prompted the teachers to look for further training in order to improve their teaching. While lesson study had a definite positive effect in one situation,

it also stimulated teachers who did not encounter immediate success to look for alternatives rather than give up on their instructional improvement.

Fernandez (2005) focused on opportunities for teacher learning within the professional development in an examination of an application of lesson study in mathematics with a group of elementary teachers. She found that teachers had opportunities to enrich their mathematical content knowledge and learned how to engage in mathematical reasoning during lesson delivery. The overall reaction of teacher participants was that they learned much about teaching in general and about mathematics instruction in particular.

Hurd and Licciardo-Musso (2005) reported on one successful lesson study implementation in literacy instruction. Their lesson study group deviated in size from the recommended four to six members and included nine elementary teachers plus a county language arts coordinator. The teachers found that their participation in the research-focused lesson study positively affected their teaching as they broadened their scope of inquiry into everyday practices. Hurd and Liscciardo-Musso concluded that teachers found lesson study effective, professionally engaging, and empowering. Their findings were supported by the work of Taylor and colleagues (2005). These authors reported on an application of lesson study with second-grade teachers working in a rural area. Teacher participants shared that the mathematics-focused lesson study work empowered and motivated them because they were able to navigate the direction of the professional development and to see immediate results in the classroom. The teachers reported becoming more successful in their efforts to improve instruction after gaining more

experience in practicing lesson study. The researchers concluded that lesson study is very suitable for implementation with mathematics instruction because it "provides a structure within which small changes gather and flow together to become the substance of new conversations and discussions" (p. 21). The study reports several challenges faced by the teachers. First, the controlling forces of mandated policies became a serious restriction toward implementing practices considered best by the teachers in the classroom. Second, these teachers also experienced growing pains when shifting from traditional to more student-centered practices. Third, understanding the goals of lesson study was a long-term process. Fourth, the teachers discovered that their lesson implementations required solid administrative support.

Lewis, Perry, Hurd, and O'Connell (2006), reflecting on a 6-year lesson study experience, emphasized a different aspect of lesson study. The elementary grade teachers involved in this long-term project found their lesson study experience to be rich with opportunities for mentoring. Their learning was further enriched when they invited "knowledgeable others"—professionals outside their particular area of expertise—for opinion and advice. Teachers said that lesson study was not only relevant to content area improvement, but it was also changing the professional atmosphere at the school to one of greater collegiality and mutual support. The variety of reported applications of lesson study suggests that the model is adjustable to the needs of the teachers, the schools, and the students, and that additional research will disclose to the research community important insights into culturally responsive lesson study and its possible impact on the education process.

Challenges for Lesson Study in the U.S.

The teacher-reported positive effects of lesson study participation on teachers' professional development and growth support the current recommendations for effective professional development previously discussed (Glickman et al., 2007; Gordon, 2004; Loucks-Horsley et al., 2003). Lesson study appears to center professional development on teacher learning and respective adult learning theories.

Although lesson study is seen as a "way to reengineer U.S. teaching" (Chokshi & Fernandez, 2005, p. 680), a mirror image of the Japanese lesson study in the United Sates is not possible for a variety of reasons. Among them are teachers' contract time and availability for meetings; teacher motivation; different teaching styles; and different cultural expectations of the Japanese teachers and their students (Chokshi & Fernandez, 2004; Fernandez, 2002; Wiburg & Brown, 2007). For example, the contract time for teachers in Japan requires them to be in school until 5 p.m. The extra hours after working with students is exactly when the lesson study meetings take place. In contrast, U.S. teachers' contract time typically ends half an hour after classes are over, and the lesson study meetings must take place during their personal time. Many teachers also fear that lesson study is a replacement for evaluation, or a demonstration of expert teaching that blindly follows Japanese teaching methods, or a process of creating one "perfect" lesson with no significant value for their own teaching. Some of these misconceptions could be corrected by using proper training in lesson study and by creating better collaboration among teachers with and without experience in lesson study.

There is another major difference between schools in Japan and the United States that can significantly affect the outcome of applications of lesson study. This difference is not addressed in the available analyses of the challenges of lesson study implementation in the United States. The original model of lesson study has been developed and established as being successful in Japan where ethnic diversity is not as great as in the U.S. The educational reality in the United States reveals a variety of diverse student groups that continuously increases in locations where most instruction is predominantly monolingual and mono-cultural. Teachers are typically trained in and practice Euro-centered teaching approaches (Brand et al., 2006). Research and practice have already established that the cultural nature of this discrepancy is one of the underlying reasons for the existing gap in student achievement in core academic areas (Ladson-Billings, 2006). This also could be a major contributor to an unsuccessful implementation of a well-planned lesson that does not contribute to student understanding and learning because of cultural irrelevance to a majority of the students present in the classroom. One possible solution to this challenge is to look into applications of lesson study from a culturally responsive professional development perspective.

Culturally Responsive Mathematics Professional Development

The ultimate goal of teachers' professional development is instructional improvement that leads to increased student achievement. Teacher learning is not an endpoint where the process of professional development becomes complete and learning must reach the students in the classroom through new and revised instructional practices.

Professional development should be responsive to teachers' *and* students' cultural values and beliefs. The increase of diverse student populations in the United States is undeniable, and schools currently struggle to meet their needs and provide them with a high-quality education that meets the established standards (Leonard, 2008). The concept of culturally responsive professional development provides opportunities for teachers to acquire the proficiency they need to change the existing situation. This type of professional development is rooted in the theory of culturally responsive teaching discussed earlier. A culturally responsive mathematics lesson study is also sociocultural in nature and responds to the cultural uniqueness of teachers and learners while offering opportunities for professional growth in a socially inviting, collaborative environment.

Farmer, Hawk, and Neuman (2005) described culturally responsive professional development for teachers of mathematics as an experience that engages teacher participants in "learning through a wide array of culturally authentic mathematical and pedagogical contexts" (p. 62) while at the same time validating their professional and life experiences. In order to become culturally responsive, lesson study professional development should provide opportunities to learn about the cultural nature of students' life experiences and how they can be related to the instructional practice of mathematics. Hollins (1996) suggested the use of cultural accommodation, in which "the most commonly used aspects of culture include socially constructed learning situations consistent with practices found in the students' home culture and culturally valued knowledge in curriculum context" (p. 145). Hollins maintained that "the primary goal of cultural accommodation is to facilitate learning in situations where teachers and students

do not share the same culture and there is a standard curriculum" (p. 145). This study involves a cultural consultant who provides advice on possible cultural elements and content of the mathematics lessons relevant to the students' cultures. The consultant also suggests formats of culturally responsive instruction that scaffolds students' learning of the subject and supports teachers' learning about the process of planning culturally responsive lessons.

Although there is limited research on culturally responsive lesson study for teachers of mathematics, some accounts provide evidence of positive effects of other forms of culturally relevant mathematics professional development on student achievement and on mathematics teachers' instructional approaches. Lipka and colleagues (2005a, 2005b) reported changes in teacher attitudes and practices as a result of participation in a mathematics in cultural context project, which involved implementation of culturally responsive curriculum developed in cooperation with Yup'ik community members in Alaska. Teachers involved in the project learned about cultural practices that connect school and the students' homes. At the same time, they were learning to teach mathematics–from simple to complex–in the context of cultural community practices. Lipka et al. (2005a) concluded that teachers had dissimilar experiences: "Different pedagogical, school, and community contexts with different teachers result in different enactment trajectories" (p. 382). Within these different trajectories, the teachers were able to develop opportunities for meaningful mathematical learning in cultural context.

Lipka and Adams (2004) used culturally relevant mathematics curriculum supplements to teach perimeter and area concepts to Alaska Native Yup'ik students. The teacher participants attended a training workshop to review concepts of geometry and to introduce the pedagogical approach for the project: to engage students in cultural activities of building a fish rack using a constructivist approach. In this study, the teachers used the curriculum in their own classroom, having attended only the workshop, without any collaborative work. The curriculum was implemented with students in urban and rural areas. Although Lipka and Adams reported significant test score gains for all students, with largest gains for urban treatment students followed by rural treatment students, they added that some teachers did not fully implement the curriculum. One possible reason for this could be that they felt limited in their ability to work with culturally relevant instruction. The lesson study of this research engages teacher participants in long-term learning about cultural relevance of instruction. In addition, the gains of the students from Lipka and Adams' study support the argument in favor of culturally relevant professional development and the resulting culturally relevant instruction.

Brenner (1998) conducted one supportive study. In creating a model of culturally relevant mathematics teaching for Hawaiian children, she incorporated three dimensions: a social dimension, concerned with an inviting classroom environment; a cultural content dimension, concerned with teachers valuing the culture of all students in the classroom; and a cognitive dimension, concerned with the preexisting mathematical cultural knowledge of the students. In her study, Brenner guided the teachers in incorporating

culturally relevant activities and instruction. However, when specific cultural guidance is not available, teachers could still make their mathematics instruction relevant to students by planning lessons that are sensitive to their diverse classes.

Sensitive Mathematics Instruction

Nasir, Hand, and Taylor (2008) suggested that the principles of culturally responsive mathematics teaching might not be applicable in classrooms where the student body is ethnically heterogeneous. They argued that "in considering heterogeneity and culturally relevant pedagogy, it may be more difficult in heterogeneous classrooms and communities to have a sense of the community that students come from; there may be greater differences in achievement and histories with school among the students as well as variety in issues that may need to be attended to" (p. 221).

The NCTM had set forth the principles and standards for school mathematics (NCTM, 2000) to provide professional guidance for all mathematics educators. The six principles for school mathematics—equity, curriculum, teaching, learning, assessment, and technology—"describe particular features of high-quality mathematics education" (p. 11). The principle of equity stated that "excellence in mathematics requires equity," and "equity requires high expectations and worthwhile opportunities for all" (p. 12). Furthermore, "equity requires accommodating differences to help everyone learn mathematics" (p. 13). Suggested guidelines for creating an equitable mathematics classroom include providing the environment and opportunities to apply background knowledge, demonstrating personal achievement, and succeeding in mathematical tasks.

These guidelines could form the blueprint of a mathematics instruction that considers the heterogeneous diverse population in many American schools today.

NCTM principles emphasized that the equity in mathematics might require that some learners—for example, English language learners—receive additional help and support from the teacher. NCTM considered teacher professional development to be the most important resource in providing that support. Flores (2007, 2008) stated, “Qualified teachers who are committed to the learning of their students are the single most important factor for students’ success” (p. 38). He suggested that educators continue to evaluate the quality of mathematics learning after shifting attention from the achievement gap to the possible reasons that cause it. Flores focused on the opportunities available to mathematics learners at school and suggested that the gap in mathematics achievement for diverse student groups is actually an “opportunity gap.” He defined this gap as “the important things that some of our students are not receiving at school” (Flores, 2008, p. 14) and argued that teachers who focus on providing quality instruction hold high expectations and teach to the strengths of the students.

Carpenter and Lehrer (1999) suggested that promoting student understanding is key to successful and meaningful mathematical experiences. They distinguish between five interrelated mental activities that lead to understanding: “(a) constructing relationships, (b) extending and applying mathematical knowledge, (c) reflecting about experiences, (d) articulating what one knows, and (e) making mathematical knowledge one’s own” (p. 20). They suggest three dimensions as critical for providing instruction that leads to understanding: “(a) tasks and activities that students engage in and the

problems that they solve, (b) tools that represent mathematical ideas and problem situations, and (c) normative practices, which are standards regulating mathematical activities, agreed on by student and teacher" (p. 24).

Secada and Berman (1999) warned that in today's schools, where great diversity among students is a norm rather than an exception, "how the ideas are applied requires sensitivity to issues of equity" (p. 34). They state that teaching for understanding that upholds the equity principle uses a variety of contexts to frame mathematical ideas in ways that "match the diversity of students in today's schools" (p. 34). Secada and Berman suggested that teachers who provide student with opportunities for articulating their thinking verbally and in writing and allow for individual construction of understanding of multiple solution strategies are the driving force behind this type of equity-sensitive teaching of mathematics.

In this study, the type of teaching that focuses on quality opportunities for learning mathematics by considering the individual characteristics of the students, providing them with worthwhile activities, and upholding high standards is referred to as teaching that is sensitive to the diverse learners of mathematics. These opportunities are created so that every student can develop understanding of mathematics. As the NCTM Principles suggests, this type of instruction should accommodate for the needs of every individual learner, regardless of ability or attitude. The lesson study is one professional development model that may successfully accommodate teachers' efforts to create and deliver this type of student-sensitive mathematics teaching.

Summary

The culturally relevant lesson study professional development for teachers of mathematics has shifted to being more student sensitive and blends the theories of adult learning with the theory of culturally responsive pedagogy. It connects teachers' ways of learning with the creation of connections with the cultures of students. This research builds on the premises of the sociocultural theory and the belief that learning occurs in the realm of socially embedded communication through appropriation of culturally specific models designed to provide greater sensitivity to teachers' constructing of effective mathematics instruction for their students.

CHAPTER III

METHODOLOGY

In this chapter, I introduce my research site in order to situate the study and its participants in their authentic environment. I provide a description of the school I refer to as the North State Middle School (NSMS). I then describe how the lesson study group at the school was formed as the social unit where the phenomenon of teachers' culturally responsive learning was examined (Merriam, 2002). I proceed with a description of the study participants, their professional qualifications, and other background information relevant to the study. My next step is a description of the research methodology of the study. I introduce case study as the design chosen for this qualitative inquiry, and outline the data collection and data analysis methods. I reflect on my own biases and the possible influence they might have on the research. I conclude by explaining the steps taken to ensure the trustworthiness of the findings.

North State Middle School

North State is a comprehensive middle school with current enrollment of approximately 1,250 students in grades six through eight. It is the only public middle school in the district. The one-story school building is welcoming, with open hallways and direction signs for visitors. Motivational posters abound throughout the school, and every classroom is clearly identified by its number, subject area, and teacher's name. In every room, there is a display of the school's mission, beliefs, and the desired results for student learning. In addition, students and visitors can find useful information about

current and upcoming school events, club meetings, fundraisers, and other activities displayed on TV screens in the hallways. The extended care and maintenance of the school speak to the effort of administrators, teachers, and personnel to offer quality education in a safe and student-friendly environment. They all go the extra mile to communicate relevant expectations to the students and stimulate their sense of ownership and participation.

The school day started at 8:20 a.m. and ended at 3:05 p.m. The school schedule consisted of eight class periods. The first period was 30 minutes long. During this class, students received grade reports, read, reflected on readings, planned for the school day, and set long-term goals with the support of a teacher. The other seven periods were 45 minutes long, with a lunch period of 25 minutes. There were 5-minute breaks between classes, when the school hallways were crowded with students in a hurry to make it to their next class on time. The school offered 15 afterschool clubs and activities, including a mathematics club, a multicultural club, and an ESL homework club. Computer labs at the school were also available for student access before and after school.

Recent reports reflected a slight decline in the overall enrollment at North State Middle School, while the number of ethnically diverse students was increasing (Utah State Office of Education [USOE], 2007). State data on the current student population showed that more than 29% of the students were from diverse ethnic backgrounds. Hispanic/Latino students were reported to form the largest ethnic group, with more than 22% of the total number of students. However, the students at North State Middle School came from countries all around the globe: Mexico, Russia, El Salvador, Guatemala, the

Philippines, Burma, the Marshal Islands, India, and Brazil are just a few examples.

The school faculty included 74 teachers in a wide variety of academic areas, from English and mathematics to ceramics and technology. While the reported trend was an increase in the diverse student population at the school, with even greater cultural diversity within the officially reported ethnic groups, the ethnic and racial diversity among teachers at the school was close to none, with about 95% of the teachers being White. These characteristics mirrored national trends and statistics on student and teacher demographics (Howard, 1999). The mathematics department at North State Middle School consisted of eight full-time teachers and one part-time teacher, with 1 to 21 years of experience. They taught a wide variety of subjects, from sixth-grade mathematics to geometry.

Reports showed that in 2007, only 49% of all Hispanic/Latino students at NSMS passed the pre-algebra criterion referenced test at a proficient level, as compared to 82% for White students (USOE, 2007). In our conversations before the study began, some of the mathematics teachers at North State Middle School voiced their concerns about the low achievement of their students from diverse ethnic backgrounds and expressed their willingness to work toward changing their instructional practices to better support the learning of mathematics.

Culturally Responsive Lesson Study Group at North State Middle School

Although research has identified possible reasons for the achievement gap in mathematics, practice-oriented actions to reduce and eliminate it have been slow to

follow (Bol & Berry, 2005; NCTM, 2004; Shoenfeld, 2002). One possible reason for the gap is that students from diverse ethnic backgrounds might be struggling in their learning of mathematics when teachers use methods that lack cultural relevance (Dilg, 2003; Gay, 2000; Hollins, 1996). These students could possess significant knowledge and understanding that are rooted in the culturally specific practices and educational traditions of their homes. When immersed in a textbook-driven, abstract way of learning mathematics practiced by many teachers in North American classrooms, they may struggle to find a common ground and link previous experiences with this way of learning (Nasir et al., 2008). The mathematics teachers, as active agents of change in the classroom, could bridge the home and school experiences of the students and work toward creating mathematical experiences that would stimulate more successful learning. The culturally responsive teaching paradigm (Gay) provided the theoretical foundation for these efforts as it "filters curriculum content" using students' "cultural frames of reference to make the content more meaningful and easier to master" (p. 24).

The lesson study professional development model allows teachers to work together on common concerns about their classrooms. The mathematics teachers at North State Middle School saw a potential in the lesson study format to specifically focus on creating the cultural connections between home and school in their instruction. Moreover, the lesson study format offered them opportunities for ongoing, long-term collaboration, which was possibly beneficial for their own professional learning and growth. As a result, the teachers formed a lesson study group that allowed them to work in a collegial atmosphere where they shared their mathematical expertise while learning approaches to

culturally responsive teaching. By blending the culturally specific educational needs of the students and the professional needs of the teachers in one professional development format, the culturally responsive lesson study of this study became a novel environment for teacher learning.

Culturally Responsive Lesson Study Framework

The lesson study professional development of this research provided an opportunity for the mathematics teachers at North State Middle School to focus on planning and teaching culturally relevant lessons through a long-term collegial collaboration. The culturally responsive lesson study implemented at North State Middle School used the lesson study cycle suggested by Lewis (2002) as a model. A graphic outline of the recurring steps of the lesson study process was presented in Figure 1. Figure 2 reflects the added focus on cultural responsiveness by including a component

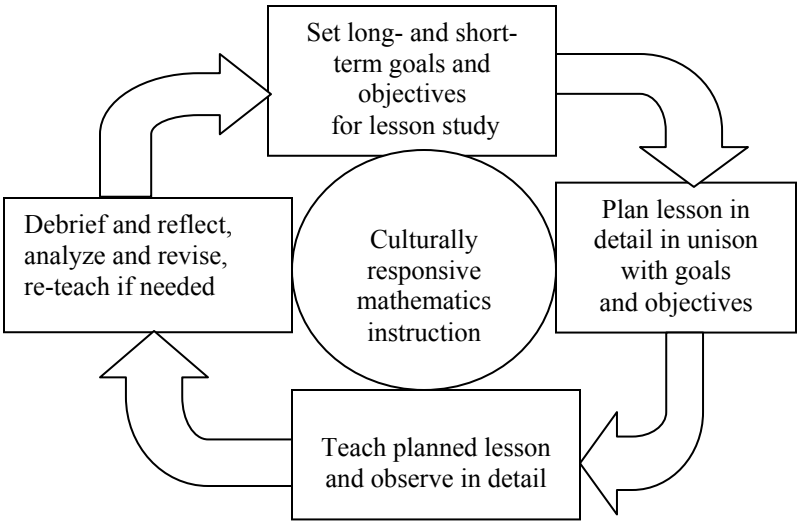

Figure 2. The culturally responsive lesson study cycle.

that is intrinsically connected to the four lesson study steps. The lesson study and its culturally relevant component created a new environment for the mathematics teachers to learn about planning and delivering culturally responsive lessons

Method

The lesson study group for this research was formed in the fall of the 2007-2008 school year, although the idea for its formation was first discussed with teachers and administrators in late spring of 2007. In April 2007, I visited with Tom, head of the mathematics department at NSMS, and introduced the lesson study model to him. His initial thought was that there would be considerable interest among the mathematics teachers because many of them had previously experienced and shared their challenges in teaching effectively to their students from diverse ethnic backgrounds. He invited me to introduce the project to the teachers during one of their department meetings. The meeting took place in September 2007.

In the spring of 2007, I also met with Gladys, who later became the cultural consultant of the lesson study group, and discussed the idea with her. She expressed interest in the project, and immediately decided it was an opportunity she would like to be involved with. She also thought there would be interest among the mathematics teachers.

After my introductory visit with all of the NSMS mathematics teachers in September 2007, I individually approached the ones who had shared initial interest with an invitation to join the lesson study group. Thus, I used purposeful sampling (Merriam,

2001a; Patton, 1990). Three mathematics teachers agreed to participate in the study: Jane, Tom, and Sid. Every one of them taught at least one eighth-grade pre-algebra class, with half or more of the students from multiple ethnic backgrounds. Gladys became a cultural consultant, and the lesson study group was formed with four participants, which is in unison with existing recommendations for the size of a lesson study team (Fernandez & Yoshida, 2004).

Study Design

A case study design was used for this qualitative inquiry. Authors define case study as a design and as a method (Creswell, 1998; Lancy, 1993; Leedy & Ormrod, 2004; Merriam, 1988; Patton, 1990; Yin, 1988). "The case study is an intensive description and analysis of a phenomenon or social unit such as an individual, group, institution, or community" (Merriam, 2002, p. 8). In addition, case study as a type of naturalistic inquiry suggests that this unit is a "bounded system," one that has limits established by people, events, or programs (Merriam, 2002, p. 10). The lesson study group and lesson study model were the unit and boundary of the study. The boundary was not set by the researcher, but by the examined system itself and the problem being investigated (Guba & Lincoln, 1981, as cited in Merriam, 1988).

Hancock and Algozzine (2006) referred to the activity, program, or situation researched as a phenomenon under investigation. They summarize that "case study research means identifying a topic that lends itself to in-depth analysis in a natural context using multiple sources of information" (p. 16). Leedy and Ormrod (2004) similarly stated that the individual or event "is studied in depth for a defined period of

time" (p. 135). This study was an in-depth investigation of the participants in a culturally relevant lesson study group over a five-month period of time.

Yin (2003) defined different types of case studies—exploratory, descriptive, and explanatory—in single- or multiple-case format. This study was a single-case descriptive study. According to Yin (1988), "rationale for a single case is where the case represents *an extreme or unique case*" (p. 47). He also stated, "A *descriptive* case study presents a complete description of a phenomenon within its context" (Yin, p. 5). In this study, the phenomenon was teachers' learning as a result of their participation in culturally relevant lesson study.

Participants

The lesson study team included four White teachers, identified throughout the study by the pseudonyms Jane, Gladys, Tom, and Sid. Their demographic information is summarized in Table 1, and the teachers are personally introduced next.

Table 1

Participants in the Lesson Study Group

Name	Age	Years of experience	Years at North State	Content area
Tom	33	10	10	Mathematics
Jane	24	1	New	Mathematics
Sid	39	10	10	Mathematics/Science
Gladys	49	12	6	ESL

Tom. Tom held a degree in elementary education and had earned the highest state mathematics endorsement. This made him a highly qualified teacher, according to the current No Child Left Behind requirements (NCLB, 2001). Tom taught pre-algebra, algebra, and geometry at NSMS and a college-level mathematics class at a nearby university. He also had ESL and technology education endorsements. Tom was involved with several extracurricular programs, including advising the mathematics club and student government.

A native to the state, Tom had never been abroad and did not speak a language other than English. He was calm, professional, and effectively organized his time to accommodate his multiple responsibilities. He quickly became a driving force of the lesson study group.

Tom's classroom held a feeling of openness and students appeared comfortable coming in, asking questions, and catching up on work. He was quick to address their concerns. In each of his two pre-algebra classes, about two/thirds of the students were Hispanic/Latino.

Jane. Jane had a degree in mathematics and was working on earning her teaching credentials. The school year that the study took place was her first at NSMS, and she had one year of previous teaching experience on the West coast. Initially she taught part time, but about a month into the study, she was offered a full-time position and gradually assumed the load. She was taking college classes toward her state teaching certification and was also a basketball coach and advisor for the basketball enrichment activities at NSMS.

Jane taught eighth grade algebra and pre-algebra. More than half of her students were Hispanic/Latino. Many of them were from migrant families, some of whom came and left throughout the school year. Jane was eager to learn instructional approaches that would make learning mathematics more relevant to her students. She had some knowledge of Spanish, but did not use the language in her teaching.

Jane was calm in her demeanor and speech. She quickly related the lesson study discussions to her own present and past experiences but preferred to quietly observe her colleagues and absorb their ideas before speaking up. Although relatively new to the school and the mathematics department, Jane appeared very comfortable working in the company of her more experienced colleagues.

Sid. Sid possessed a degree in geology and had earned endorsements in integrated science and physics, plus a mathematics endorsement at a level that allowed him to teach certain core mathematics classes. He served on a number of committees that occupied a great amount of his available time.

Before coming to NSMS, Sid taught college-level geology for four years. At NSMS he taught eighth grade science and eighth grade pre-algebra. His pre-algebra class had 27 students with more than one-half of them being Hispanic/Latino. Sid did not know any languages other than English and had lived only in the U.S.

Sid came to the project very enthusiastic and willing to work, but he had many other commitments and this affected his involvement. When in attendance, he participated wholeheartedly and contributed to the lesson study work and its progress. He was eager to learn as much as possible about the most recent educational research and

demonstrated solid theoretical background in research-based instruction.

The Role of the Cultural Consultant

The original lesson study framework includes a person called a "knowledgeable other" – "educators with expertise in content or pedagogy relevant to the research lesson" (Stepanek et al., 2007, p. 5). Wiburg and Brown (2007) specified that persons in different positions and with different expertise could fulfill this role as "instructional coaches, university faculty, principals serving as instructional leaders, outside consultants, or teachers who have experienced and worked with lesson study at least a year or two" (p. 95). This individual plays a role in all phases of the lesson study process, from early planning to the final summary of the experience.

The role of a knowledgeable other in this research was assigned to a "cultural consultant." I define the cultural consultant as an equal member of the lesson study group who has knowledge and experience learning, teaching, and living in different cultures. The cultural consultant also brings to the lesson study team knowledge of language learning, educational traditions, and schooling in different cultures. The term "cultural consultant" was chosen over "knowledgeable other" in an effort to avoid association with some possible hierarchy of positions between the mathematics teachers and the consultant.

Gladys. Gladys taught English as a second language in the Alternative Language Program. She was originally from Australia, but her life experiences spread across continents. As a college student, she worked at a Polynesian cultural center in Hawaii. Next, she lived and worked in various parts of the United States before moving to

Germany. She then went to Turkey, where she earned a certificate to teach English as a foreign language. She became fluent in the Turkish language and spent several years teaching English to elementary and secondary students and adults. Even though she left the country almost a decade ago, Gladys continues to maintain her knowledge of the language.

Her teaching experiences continued in England, where she trained English-language teachers from different countries. After moving back to the U.S., Gladys attended school and earned a bachelor and master degrees in education with a minor in art. She added endorsements in ESL, mathematics, middle-level education, and early childhood education. She completed classes on diversity in education and multicultural mathematics as part of her studies.

Gladys' concern about the success of her students showed through her involvement with the student clubs at North State Middle School. Four days a week, she supervised the ESL homework room. She was also the advisor for the Multicultural Club and the Mathematics, Engineering, and Science Achievement (MESA) Club.

Gladys was not a representative of the Hispanic/Latino culture, which describes the largest diverse group at the school and did not speak the Spanish language. These must be considered limitations of the study. It might be argued that the ideal person for this role would be someone who intrinsically shares the ethnic and cultural background of the majority of the diverse students in the classroom. Although Gladys did not fit this criterion, she was chosen as someone with substantial and eclectic knowledge of the connections between culture and education. She possesses expertise in teaching language

learners from different cultures with extensive personal experience.

The participation of a cultural consultant was supported by Chokshi and Fernandez's (2004) recommendations for successful applications of lesson study in the United States: engaging knowledgeable others as key figures for "providing information, guidance, and feedback at critical junctures of the lesson study process" (p. 525). Gladys focused the group on possible cultural and linguistic connections between mathematics teaching and learning in a culturally responsive way. She also guided the work relevant to a culturally responsive implementation of these connections into the lessons and classroom (Gay, 2000; Hollins, 1996). As Chokshi and Fernandez asserted, such combinations allow for lesson study to be teacher-driven and involve expert competencies from a variety of professionals.

The Role of the Researcher

I initially saw myself as an observer who used multiple data collection procedures to provide thick, rich descriptions of the processes that accompany participation in lesson study and the relevant learning of the teachers. My participation began in the spring of 2007 when I initiated the lesson study group and began recruiting teachers to participate. My impression immediately following the first department-wide informational meeting was that the teachers considered me as the person "in charge" of the proposed group. This reaction was partially expected because most professional development has a designated individual who is responsible for the organization and delivery of the sessions (Glickman et al., 2007; Loucks-Horsley et al., 2003). One of the unique features of lesson study, however, is that the group members are in charge of their own professional development

(Lewis, 2002), and I emphasized this feature during the introductory meeting with the mathematics faculty.

I reiterated the teacher-centered nature of the lesson study to those who agreed to participate. I delivered a lesson study workshop in which I introduced the lesson study in more detail and emphasized possible pitfalls as found in previous research. We discussed how the meetings and the discussions would be organized. It became clear that the teachers had a multitude of responsibilities that took place after the school day was over at the time when the lesson study meetings would be held. The group members pointed out that having weekly meetings might be a logistical problem due to conflicting schedules. The initial idea to meet on the same day at the same time every week failed since the teachers' schedules and responsibilities changed often and on short notice. The teachers clearly stated they would rather have me be in charge of scheduling and reminding them of upcoming meetings and responsibilities. Sid, for example, told me that if I checked with him often to remind him about the meetings, he would be able to participate. After 2 weeks of regular visits to the school, I was convinced that the teachers' loads were numerous and varied, and that scheduling and organization were of greatest importance.

My role started changing from that of an observer to somewhat of a participant. I would describe my participation as a modification of the "observer effect" (Bogdan & Biklen, 1982, p. 43) rather than as a participant observer. As Bogdan and Biklen suggested, the researcher's place on the participant/observer continuum is quite specific to every study. Helping participants with their tasks is acceptable, "but always for the

reason of promoting your research goals" (p. 43). I agreed to manage the work schedule of the group due to my understanding of the need to have someone in charge of scheduling. As a teacher and researcher, I felt responsible for fulfilling this role so the teachers could focus on their lessons. By the time this issue became a threat, the lesson study group was already formed and learning. Every week, the teachers provided their individual availability for the following week. I then determined one or two possible meeting days and informed everyone, in person or by e-mail, of the next meeting.

I am also a mathematics teacher, and the members of the lesson study group were aware of this. During discussions on particular mathematical content, they would occasionally ask what I thought about an issue. I would share my opinion, and would then continue taking detailed notes of the meeting. The teachers also knew that I had teaching and learning experiences in different countries, that English was not my first language, and that one of my children was a student at North State Middle School. It would be a challenge to determine how my background and presence affected the planning and the outcome of the lessons. I was mostly invited to participate in the discussions if a lesson study member was absent. Gans (1982, as cited in Merriam, 1988) calls this a "researcher participant," or a researcher who takes part in social situations relevant to the research but still acts as a researcher because he/she is not a complete participant. Again, my role changed from one of a schedule manager, and this change strengthened my relationship with the teachers. They were accepting of me not just as someone who was closely observing their work, but also as a colleague who had similar concerns about mathematics teaching. I believe this contributed to their level of comfort

throughout the study.

At the same time, the team members did not expect me to fully participate in the planning of the lessons; the decisions were entirely theirs and I did not formally contribute to the final lesson plans. I believe that building my own role within the lesson study group as a coordinator and a sounding board for ideas was important. The teachers invested extra time and effort into creating the lessons, and they felt relieved not to be responsible for organizing the meetings. At the same time, they appeared comfortable coming to the meetings, talking about their professional experiences, discussing them with colleagues, and sometimes sharing a good laugh.

In summary, I approached this project as a researcher who is a tool of the investigation (Bogdan & Biklen, 1982; Creswell, 1998; Hancock & Algozzine, 2006; Leedy & Ormrod, 2004; Merriam, 1988; Patton, 1990). To achieve this, I used "rigorous data collection procedures" (Creswell) described in the following sections. In addition, I maintained my own journal that reflected on meetings and lessons taught by the group members. The study and the relevant data collection evolved as the processes within the lesson study group unfolded.

Types of Collected Data

The data for the study were collected from observations, interviews, and team meeting documents. Collection of observational data started from the moment I visited the school to recruit teacher participants and continued throughout the duration of the study. I observed all 17 activities of the lesson study group over a 5-month period. I collected field notes from all planning, discussion, and analysis meetings of the group as

well as each of the lessons they taught. Merriam (2001a) suggested different categories of observational data: the physical settings, the participants, activities and interactions, conversations, subtle factors, and researcher's own behavior. I created a summative account of the settings, the participants, and their interactions and activities. In addition, I made every effort to record and reflect on possible subtle factors (nonverbal communications, unplanned activities, etc.) that accompanied the visible interactions and also took record of my own behavior, as suggested by Merriam and by Glesne (2006). I made records of all informal conversations relevant to the study (outside the planned meetings and activities) that I had with the participants on different occasions. I provided in-depth observation of the phenomenon by reflecting on a variety of contributing factors, including the researcher's presence and attitude.

I wrote a narrative of the events of my observations. I found this method of recording more convenient for data analysis. I typed my hand-written notes immediately following the meetings. Sometimes, during the teachers' discussion and planning, it was difficult to record the natural flow of the conversation without missing pieces of the discussion. I made an attempt to audio record a conversation, which proved helpful but still challenging when trying to understand the speech of the participants and connect their statements with what was accompanying the discussion–drawings, examples, etc. This is why I continued to take hand-written notes of the contributions of every member of the group and then type them in as much detail as I could recall. I also included in my observational notes any drawings and other details that might help me with recollection of the observed meeting. I maintained the records in chronological order. I accounted for

happenings at the school and in the community that possibly had an effect on the events that were the focus of my observations in order to further situate the lesson study group and its work within the school and its dynamic life.

Interviews were another data collection instrument for this exploration that allowed me to be "in search of opinions, perceptions, and attitudes" (Glesne, 2006, p. 80) about teachers' lesson study group participation and learning. I conducted three interviews with each participant, one after each lesson they planned and taught. These interviews were between 45 and 60 minutes long and were conducted at each participant's convenience. The interviews were audio recorded, transcribed, analyzed, and given back to the teachers for member checking (Glesne). I scheduled the interviews within a week of the discussion session after a lesson was taught. The interviews were conducted at teachers' preference in their classrooms at the school. This setting appeared conducive to better recall the planning and delivery of the lessons, and the teachers also had the familiarity of their classrooms and school as a backdrop for staying focused on their students and the lesson study. One setback of this arrangement was that students, other teachers, or intercom announcements would sometimes interrupt the interview. The teacher then needed to refocus back to our conversation, and with a quick reminder of the point where the conversation was stopped, we were usually able to continue.

The preferred interview instrumentation for this investigation was the interview guide approach. I created an outline that contained the topics and issues to be covered in each interview. I did not ask the questions in a strict sequence or read them verbatim from the outline (Patton, 1990). Questions for the interviews emerged from the study

questions, my observations, other conversations with the participants, and the interviews themselves. I carefully revised every outline before and after each interview in order to avoid inadvertently leaving out important, relevant topics. Some questions originated in an interview with a participant, and I added the question to the outline when I interviewed another teacher. I also made every effort to include an omitted topic as part of a subsequent interview.

The interview guide approach allowed for adapting the questions and the flow of the interview with respect to the role of the interviewees in the project and their specific responsibilities within the group and the lessons. At the same time, this approach allowed for comprehensive data to be collected somewhat systematically from each respondent (Patton, 1990). Since the study design involved multiple interviews with four participants reflecting on the same phenomenon, the open-ended nature of the questions allowed for capturing the reflection of every teacher participant on his/her lesson study experiences. Still, the pre-established interview content led to systematically collecting teachers' inputs on the same issues. Other strengths of this type of interviewing that became apparent throughout the study were its conversational nature and the opportunities to close gaps in data by adding questions relevant to the topic and asking for clarification and more details. These strengths also contributed greatly to my goal of "seeing without being seen" (Glesne, 2006, p. 73) – conducting interviews with minimal awkwardness between interviewer and interviewee by following a more natural sequence and flow.

Another data source for the study was the collection of documents produced by the teachers during their lesson study meetings. These included copies of their planning

and observational forms, drawings, students' assignments, and assessment rubrics. These documents were authentic artifacts of the teachers' thinking processes while learning to plan and teach culturally relevant lessons. They were also the link between the professional development and the instructional processes. When discussing and revising a lesson, the teachers used these documents to support their claims for a successful teaching experience or for a needed change.

In the beginning of the study, I gave every participant a folder with lesson study materials and a journal notebook. I asked every teacher to record their immediate thoughts before, during, and after lesson study meetings. It soon became clear that the teachers preferred to verbally express their thoughts rather than writing them in a journal. I realized the teachers would not maintain the journals, and if they did, they would write short notes from the meetings rather than an actual personal reflection of the events. I reminded them several times, but understood that these reminders put more pressure on them. I decided not to push the journal writing any further, and let the teachers decide if they wanted to write in them. Instead, I tried to talk briefly with the teachers individually after the meetings to hear what they thought and had to share. I then recorded their thoughts myself. The data collection sequence and timetable are presented in Table 2.

Table 3 provides additional detail on the timeline and topics of the group's meetings and a summary of the chronological order of the lesson study group work. This allows for a quick reference to the length of a lesson study cycle and the number of formal observations per cycle.

Table 2

Data Collection Sequence and Timetable

Month/year	Activity	Collected data
November 2007	Lesson study group organized	Field notes, journal
December 2007	Lesson study workshop	Field notes, journal
December 2007 January 2008	Weekly meetings, planning lesson one	Field notes, documents, journal
January 2008	Lesson one teaching, debriefing	Field notes, interviews, journal, documents
February 2008	Weekly meetings, planning lesson two	Field notes, documents, journal
March 2008	Lesson two teaching, debriefing	Field notes, interviews, journal, documents
March 2008 April 2008	Weekly meetings planning lesson three	Field notes, documents, journal
April 2008	Lesson three teaching, debriefing, closing	Field notes, interviews, journal, documents

Data Analysis

I analyzed the collected data using the constant comparative data analysis method, defined as "moving back and forth between data collection and data analysis, with data analysis driving the data collection" (Leedy & Ormrod, 2004, p. 141). Scholars agree that there is no uniform way to analyze qualitative data (Creswell, 1998; Patton, 1990). Merriam (2001a) stated, "data analysis is a complex process that involves moving back and forth between concrete bits of data and abstract concepts, between inductive and deductive reasoning, between description and interpretation" (p. 178). To assure that I provided this depth and detail in learning about the lesson study group and its actions, the

Table 3

Meeting Topics and Data Collected

Meeting	Date	Present	Topic	Collected data
One	December 4	Gladys, Tom Jane, Sid	Lesson study	Observation notes Informal conversations
Two	December 11	Gladys, Tom Jane	Lesson study Sensitive teaching	Observation notes Documents
Three	December 20	Gladys, Tom Jane, Sid	Lesson one plans	Observation notes Documents
Four	January 3	Gladys, Tom Jane, Sid	Lesson discussions	Observation notes Documents
Five	January 16	Jane, Sid	Lesson discussions	Observation notes Documents
Lesson One	January 28	Gladys, Tom Jane, Sid	Sid teaches	Observation notes Observation protocols Documents
Six	January 30	Gladys, Jane Sid	Lesson one debriefing	Observation notes Audio recordings
Seven	February 7	Gladys, Tom Jane, Sid	Lesson two plans	Observation notes Documents
Eight	February 11	Gladys, Tom Jane	Lesson discussions	Observation notes Documents
Nine	February 21	Gladys, Tom Jane, Sid	Lesson discussions	Observation notes Documents
Ten	February 28	Gladys, Tom Jane, Sid	Lesson discussions	Observation notes Documents Audio recordings
Eleven	March 7	Gladys, Tom Jane, Sid	Lesson discussions	Observation notes Documents
Lesson Two	March 14	Tom, Jane Sid	Jane teaches	Observation notes Observation protocols
Twelve	March 27	Gladys, Tom Jane	Lesson three plans	Observation notes Documents
Thirteen	March 31	Gladys, Tom Jane	Lesson discussions	Observation notes
Fourteen	April 3	Gladys, Tom Jane	Lesson discussions	Observation notes

(*table continues*)

Meeting	Date	Present	Topic	Collected data
Fifteen	April 17	Gladys, Tom Jane, Sid	Lesson discussions	Observation notes
Lesson Three	April 22	Tom, Jane Sid	Tom teaches	Observation notes Observation protocols

comparative analysis of the data was continual, and it naturally followed the three major cycles of the lesson study group, with one for each lesson planned, taught, and discussed.

I connected the data collection and the data analysis approaches in order to support the data analysis. For example, my field journal was a notebook where I wrote my observation notes only on the right pages. I used the left pages to record any additional notes, insights, and connections that revealed and illustrated themes within the study and those that informed the ongoing data collection. I found this approach, a modification of the observation protocol suggested by Creswell (1998), to work better because it provided me with room to write observational notes and with enough space to record multiple notes pertaining to the analysis. I also obtained the team's permission to record parts of some group meetings. These events were fast-paced discussions, and I had to make a choice to write observations and miss pieces of the discussion and the accompanying drawings the teachers created, or record the discussion and then re-write the observation notes by combining the dialog from the recordings and everything else I wrote in the field journal. This approach allowed me to focus on interactions and supporting events without missing the discussion and informed my data analysis by providing great detail. A setback here was the occasional difficulty in distinguishing the speech of the participants from the audio file.

I made the first steps toward data analysis while transcribing the interviews with the teachers. I transcribed them myself and the process, although lengthy, gave me the opportunity to redo every interview again and again. I made an effort to transcribe the interviews as soon as possible after the actual interview took place, while the reactions and body language of the interviewee were still fresh in my mind. I then listened again to the whole interview and corrected any possible typos and omissions. I added any additional reactions and fillers that I did not record the first time. While doing this, I also took short notes on the side. This helped my efforts to conduct in-depth analysis because of the multiple opportunities for hearing and recollecting the discussions with and between the teachers.

I arranged the one-sided prints of the interviews in a three-ring binder. I used the left-hand blank paper to write notes and reminders. I added references to other interviews, the observation notes, or my journal. This structure was a strong visual support for the analysis and a timely referral to a participant's point of view.

The notes I wrote in the margin supported the development of the coding categories for the study. I underlined words and phrases in both field notes and interview transcripts and started creating a list of codes. This list was a work in progress and sometimes with the advancement of the study, I combined two or more categories, while dropping some other categories from the list. I assigned a number to each category and identified the theme in the respective file.

During this process, I used a great amount of visual help and I created as much visual representation of the data pieces as possible. First, I printed color-coded copies of

all interviews with a color assigned to each participant. In addition to underlining and highlighting the quotes that were guiding or supporting the study themes and writing the codes, I used white posters to graphically display the themes and codes identified within each of the three lesson cycles. With the accumulation of more data, I benefited from having them visible at all times. I was able to identify if a theme was present in more than one lesson study cycle, or if a new theme was identified. I wrote the themes on sticky notes and attached them to the posters, which allowed for their easy manipulation on the board.

This method of organizing the analysis proved helpful when I was working on grouping the findings from all lessons into common themes and categories. It was quite convenient and still visually supportive to move and reattach the notes. I used colored poster boards to distinguish between the initial, ongoing analysis and the final study analysis after all data were collected. I still used post-it notes; they contained either the text I first wrote when I identified the data code name, or new text that summarized several previously identified codes. I graphically presented possible connections between the coded categories and worked with this visual representation of all themes and codes on the boards.

Trustworthiness of Findings

The first factor in ensuring the trustworthiness of this study was its long-term exploratory nature supported by a continuous collection of data. I observed every meeting of the lesson study group and kept detailed field notes. I used this data to provide rich, thick descriptions of the participants, their environment, and their collaboration. In

addition to this ongoing process, I conducted multiple interviews with each participant in order to describe and analyze the lesson study group and the teachers using their own voices. I used open-ended interview format, which allowed for exploration of participants' point of view. The data collected from observations and interviews were further triangulated with the documents of the lesson study group. These three data sources provided thorough exploration by compiling the notes of the observer with the teacher's own verbal reflections and with the actual written pieces produced by the teachers as one outcome of their lesson study work. In addition, I asked participants to provide member checking of my analysis. Their input on the truthfulness of the accounts and on the accuracy of representing their thoughts, actions, and feeling was taken into consideration in the final analysis and narrative.

I used the suggestions made by Merriam (1998) in planning these approaches for trustworthiness. She listed six strategies for enhancing the validity of a qualitative study: triangulation, member checks, long-term observations, carrying out a participatory or collaborative form of research, clear statements of author's biases, and peer examinations (p. 204). Although I was not a lesson study group member, my participation in the study was not limited to just that of an observer and interviewer. My background as a mathematics teacher and parent of a child who is part of its diverse student population at NSMS, in addition to my past personal and professional contacts with at least two of the teacher participants, determined my role as different from a typical outsider observer. Therefore, my biases became inseparable from the data collection and interpretation because I was the instrument of the exploration.

I am a mathematics teacher, as the participants in the study are, and my training and philosophy of teaching were not necessarily similar with the teaching approaches adopted by the lesson study group and its members. I have been trained in teaching in two different cultures and have my own beliefs about teaching in culturally relevant ways. I have sound theoretical background on lesson study and its applications in Japan as well as in the U.S., but I have not been part of a lesson study group. My understanding of how a lesson study team should work and progress might have overlapped with the goals and objectives of the teachers. As a parent of ethnically diverse students, I have built a vision of the potential impact of culturally relevant mathematics instruction and how to achieve this relevance in the classroom. My understanding and beliefs might have affected the representation I provided.

I reflected on the possible influence of my biases in my personal journal. I continuously used reflective practices when collecting and analyzing data so that my personal beliefs were identified and their possible influence on the study was made known to the readers and myself. Glesne (2006) called this process "monitoring and using subjectivity" (p. 123) and asserted, "You learn that your subjectivity is the basis of the story that you are able to tell." Even my presence in a researcher role might have distorted the data from the teachers. To minimize this possibility, I made every effort to build good rapport with the teachers and maintain good relationships with them outside the study meetings. I used the member checking technique to give the participants the opportunity to review their input without me present to avoid possible distortion of data due to my involvement. Since the teachers were extremely overloaded and showed signs

of burnout, the planning and teaching of the third lesson in the study was delayed and rescheduled for April. Instead, I asked them to read and provide feedback on a limited number of pages that included my analysis of their expressed opinions and observed actions. I was able to receive their input in support of the trustworthiness of the study without jeopardizing further the work, my access, and my contacts with the lesson study group.

Summary

Hollway and Jefferson (2005, as cited in Gesne, 2006) suggested that researchers continuously answer four questions while working with their data:

1. What do you notice?
2. Why do you notice what you notice?
3. How can you interpret what you notice?
4. How can you know that your interpretation is the "right" one?

Active reflection and honest answers to these questions allowed me to be immersed continuously in the data collection and analysis. I created a description that is unique because I am the one telling it. I understand that this story might be different if it were told from a different perspective; however, I used the recommendations of experts in the field of qualitative inquiry to ensure that my story was trustworthy and in-depth. I also relied on the authentic voices of the participants and on their professional and personal involvement with the research to reconstruct the events on paper in a truthful way. My analysis is not the only way to interpret the events and their meanings. Still, I

believe it is a trustworthy accounting of events and a reference for further exploring lesson study as a model of culturally relevant mathematics professional development and its role in education.

CHAPTER IV

METHODOLOGY AND STUDY REVISED

The study, as originally planned, was focused on culturally relevant lesson study As the study progressed, it became apparent that a number of issues and challenges shifted the emphasis, making it impossible to adequately implement and research cultural relevancy in this professional development effort. This chapter will detail those revisions to relocate the emphasis to student-sensitive lesson study.

The lesson study model was envisioned as a collaborative effort to develop and teach culturally responsive mathematics lessons. The study's teacher-driven nature put the participants in charge of lesson content and pedagogy. This allowed the teachers to focus their efforts on planning and implementing instructional activities that were student-centered.

The Need for Revision Explained

The lesson study team decided on topics, approaches, and activities after considering the challenges they face in addressing the multiple needs of learners in their classrooms. The shift from culturally responsive lesson study to student-sensitive instruction occurred because of teachers' current experiences and observations about students at NSMS and because of the lack of specific guidance about culturally responsive teaching. The team members recognized the need for change in their instructional approaches when working with students from various ethnic backgrounds, and demonstrated this by joining the lesson study group. It appeared, however, that they

did not support the envisioned cultural relevance of the lesson study as applicable to their classrooms. Tom explained when he said:

> It is just getting so diverse…your population is just getting so diverse! You know that…you are not going to have a class of 15 kids who just barely moved from some South American country in here. A lot of the ESL students that are in that class, they grew up here. They've lived here … they were born here, their parents moved here, you know, so they speak Spanish at home (…) But they grew up going to the roller blade [rink] here and going playing soccer here, and I mean…. They still hold on to a lot of their traditions, from Central and South America, but …And you do get those kids that just moved in straight from Ecuador or whatever, so it is…even within the minority group, it is a huge…huge diverse population of where they are coming from. And that's…that makes…I mean trying to find cultural relevance there's hard, because you know the kid spent… the kid [who grew up here] has…different cultural relevance from Mexico, from Ecuador, from…so it's just…it's just so large. You don't have just one class where you just have one group of kids any more, that doesn't happen.

Even though most of the pre-algebra students were Hispanic/Latino, the teachers and the consultant decided that the use of a specific activity from one country would not be relevant to most of them because of this enormous "diversity within the diversity," as Tom put it. In their lesson study, the teachers indicated they wished to consider interests of their students and specific experiences or activities students might enjoy. Teachers began looking for effective instructional approaches that might engage these students in the successful learning of mathematics, but these approaches were not culturally relevant.

The student-sensitive work of the lesson study group originated in teachers' beliefs that mathematics should be taught in a way that every student in the classroom understands. The lesson study became aligned with the work of Romberg and Kaput (1999) and their claim that mathematics should be taught in context, through tasks that are relevant to the students so that they could make meaningful connections to the problems and inferences from the findings. The lesson study work supported the idea that

understanding is unique for every learner, but applications that require articulation of the knowledge allow students to claim ownership (Carpenter & Lehrer, 1999). The team members approached the lesson planning process understanding that it was their responsibility to provide optimal opportunities allowing their students to learn most effectively, as it was well aligned with the principle of equity for teaching mathematics (NCTM, 2000).

One influence on the teachers' decision to plan and teach lessons that were student-sensitive could have been the novelty of both lesson study and cultural responsiveness of instruction to the teachers. The lesson study appeared a simple and straightforward collaborative model that engaged teachers in ways different from the traditional professional development they have participated in before. It required high levels of teacher initiative and action, as well as ongoing preparation and contribution. It also included observations from colleagues that were a source of additional stress and anxiety. The lesson study format provided the teachers with opportunities that were aligned with the theories of effective professional development and adult learning, but it required substantial effort to become accustomed and comfortable to this type of collaboration. When the culturally relevant component was proposed as part of this new, not yet mastered professional development, it added more than the team members were able to handle at the time. As a result, the teachers chose to continue working in the lesson study and develop lessons that provided opportunities for learning mathematics (Flores, 2008) in a student-sensitive way.

The Role of the Consultant Revised

The central role of the lesson study consultant in determining the direction of the group's work also affected this shift from the sought cultural relevance of mathematics teaching. Gladys was not a member of the Hispanic/Latino ethnic group, the largest at NSMS, and was not proficient in the Spanish language. She did not have the ability, given that she was not a member or expert of the students' ethnic group, to build on the inclusion of their culture in mathematics instruction. She also lacked sufficient knowledge of culturally specific mathematical practices. Although she had a solid background in multiculturalism and education, she lacked the in-depth knowledge of, and experience with, culturally relevant instruction. These factors affected her ability to build a convincing case about culturally responsive teaching and its applications in mathematics, which in turn affected her capability to communicate her case to the teachers.

These limitations in Gladys' participation called for a revision of her role as cultural consultant. Gladys brought to the study a wealth of multicultural experiences including ESL certification, foreign language teaching, educational experiences in the United States and abroad, and a contagious dedication to improve the educational opportunities for the increasingly diverse population at NSMS. Gladys helped the team recognize the need for vocabulary development in mathematics classes, and continuously stressed effective instructional strategies for ESL students. Her consultant role incorporated many aspects of her ESL training. She enriched her contributions with examples and experiences related to education and the teaching of mathematics in

different countries, and included her personal observations of practices in American classrooms that negatively influenced students' understanding of mathematics. The inclusion of this multicultural knowledge showed that Gladys' participation expanded beyond ESL advising, and her position was reformulated as one of a diversity advisor for the team.

Study Questions Revised

The revised purpose of this investigation was to explore how teachers' participation in student-sensitive mathematics lesson study influenced their learning, mathematics teaching, and classroom practices as they planned and taught lessons with the support of a diversity consultant. The focus was on three guiding questions.

1. How did student-sensitive lesson study affect teachers' learning about mathematics instruction for diverse student groups?
2. How did teachers' participation in student-sensitive lesson study influence their attitudes toward planning and delivering mathematics lessons to students from diverse backgrounds?
3. What factors affected teacher's participation in and learning from this student-sensitive lesson planning and delivery?

Methodology Revised

Student-Sensitive Lesson Study Framework

The implementation of the student-sensitive lesson study at NSMS was accompanied by an alteration to the lesson study framework. According to Lewis (2002),

the complete lesson study cycle includes four steps: setting goals and objectives, lesson planning, lesson teaching, and lesson debriefing and refinement (Figure 1). The fourth step might also include lesson reteaching, if found necessary by the team. The cycle is repeated with every new lesson.

The student-sensitive lesson study explored in this study was the first such experience for the team members. They learned about the lesson study from my presentation at the very beginning of the group work and began planning lessons. Experts on lesson study recommend that the best way to learn and know lesson study is to practice implementations that are close to the original model (Lewis, 2002; Stepanek et al., 2007).

The lesson study group began their work following the lesson study cycle; the first lesson included all four steps of the process without reteaching. During the second lesson, the team followed the first three steps closely, but the debriefing was a more informal visit between members of the lesson study team rather than an in-depth team reflection during a designated team meeting. This cycle was an alteration of the original lesson study. One reason for this was the postponement of teaching lesson two for a week due to extra time needed for planning. In addition, school responsibilities made it impossible for the team to meet the week that followed the lesson teaching. With limited time to plan and teach lesson three because of end-of-level testing, the team began the third cycle immediately without dedicating extra time to formal debriefing.

The change continued with the third lesson study cycle, which had no debriefing session. Multiple efforts to get the team together were unsuccessful. The team members

were occupied after school and could not determine a day to meet. Still, all teachers mentioned that they planned to teach the lesson to their classes in the exact way it was planned and taught, and possibly felt that a debriefing meeting was not justified. In addition, they were under great pressure to prepare their pre-algebra students for testing and preferred dedicating more time to their students.

These modifications in the fourth step of the lesson study cycle led to a revision of the student-sensitive lesson study framework. Step four did not include the optional re-teaching of the lesson, and it did not contain any group-initiated lesson revisions. These changes along with the fact that the debriefing session was held at the team's discretion for only part of the lesson study work are reflected in a revised fourth step of the student-sensitive lesson study cycle presented in Figure 3. The fourth step now includes a voluntary debriefing session.

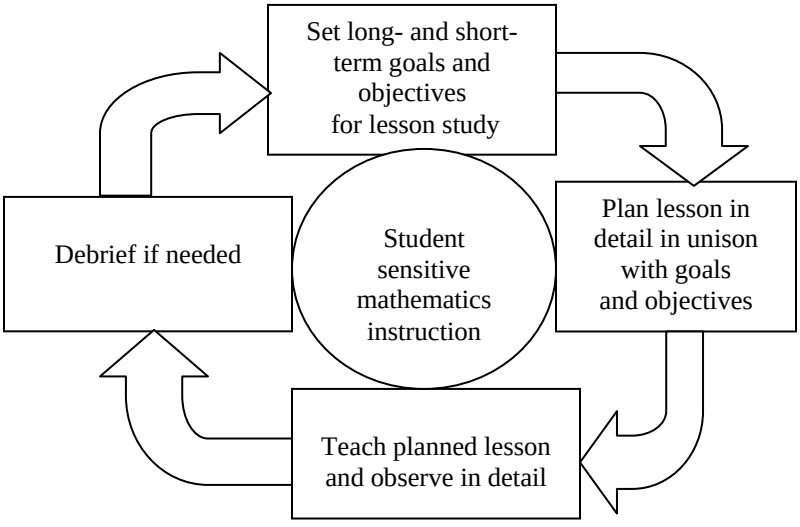

Figure 3. The student-sensitive lesson study cycle.

Study Design

The examination of the student-sensitive lesson study team included a case study design as initially planned. The unit of analysis for the study was now the revised lesson study model (Figure 3). The exploration was a descriptive case study (Yin, 2003), focused on teachers' learning because of their participation in the student-sensitive lesson study.

Participants

The participants in the student-sensitive lesson study remained the same. Sid, Jane, Tom, and Gladys initiated and embraced the change from culturally relevant to student-sensitive instruction planning. Their role, contributions, and reflections remained important to the study.

The change in Gladys' role for the study was significant but was in unison with the shift in the lesson study work. As a diversity consultant, she still actively contributed to the work of the group. Her position was still considered one of a knowledgeable other (Stepanek et al., 2007) because of her area of expertise and its relevance to the student-sensitive lesson study.

The Role of the Researcher

My role as a researcher and observer of the study remained the same. I organized and observed all lesson study meetings and dedicated my efforts to being a tool of this investigation. The student-sensitive nature of this lesson study presented worthwhile opportunities for thorough exploration of the teacher's learning.

Data Collection and Analysis

The data relevant to the student-sensitive lesson study were collected from observations, interviews, and team meeting documents (see observation protocol included in Appendix A). It was analyzed using the systematic data analysis procedures suggested by Creswell (2003). I began by reprinting, organizing, and re-reading the interviews with the teachers. I then re-visited the other data and began writing guiding notes. I then started linking topics that appeared throughout, and created a list that guided me in searching for connections that defined the categories. I continued to examine the data sources and these tools of analysis, still using the data analysis approaches outlined in Chapter III. The results will be described in Chapter V.

CHAPTER V

RESULTS

The last bell for the day rang, and the school building quickly overflowed with hundreds of energetic, loud boys and girls. It was hard to see through the crowds, and I chose to wait for a couple of minutes before navigating the labyrinth of hallways. The noise soon moved to the cold outside, and I made my way to the math hall quickly and uneventfully. The first thing I noticed when I entered Tom's room was that his class rules were posted right by the door. There was not any space left on the walls; the mathematics posters, students' work, and formulas were all over. The white boards that hung on two opposite walls displayed class information: a starter and a learning goal for the day, in-class work, and homework assignments. Right by Tom's desk, a large poster informed students what materials they would need every day of the week. A caddy full of calculators, two computer stations, and an overhead seemed to complete the technology equipment. With the students gone for the day, all of the chairs were lifted on the top of the tables. Tom and I put five chairs down, and chatted while waiting for Jane, Gladys, and Sid to join us.

Introduction to Lesson Study

We were about to begin an introduction to lesson study, and I was anxious to find out if Sid would decide to become a member of the lesson study group. Jane, Gladys, and Tom had already confirmed their commitment to lesson study. Sid also expressed enthusiasm about the project, but after stepping back and looking at his schedule, he told

me he was unsure if it would be possible to fit this additional load with his many other responsibilities. I invited him to the introductory meeting to receive firsthand information on the work and then decide. The meeting was planned to introduce the foundation of lesson study to the group. I was prepared to provide a lot of detail but wanted to engage all four participants in a discussion. Lesson study is a teachers' endeavor, and their understanding of the model, buy-in, and readiness to apply it were most important.

Gladys and Jane came in exactly on time and Sid rushed in a few minutes later, apologizing for being late. I opened the meeting by talking about lesson study origin and about its positive influence on Japanese education and teacher professional development. I handed a folder with sample lesson study materials (Lewis, 2002; Mills College, 2007) to everyone, and related them to the lesson study cycle, which was already familiar to the group. The folder included an explanation of the lesson study cycle plus examples of goal setting suggestions, lesson study planning forms, and observation guidelines.

The teachers around the table were quiet while they listened attentively, but I was becoming concerned that my presentation was turning into one of the dreaded professional developments they had seen and heard multiple times. Existing guides on lesson study work (Lewis, 2002; Stepanek et al., 2007; Wiburg & Brown, 2007), however, recommended solid introductory preparation of the lesson study team before the actual work began so that multiple threats to this collaborative effort were minimized or eliminated. I had to balance the necessary preliminary information about the lesson study format of the work with the practice-relevant topic that brought this group together. Before we turned to planning student-sensitive mathematics instruction, however, I

suggested that the teachers made specific decisions about the group because they, as educators, would be in charge of the lesson study. The atmosphere changed in an instant, and the teachers became actively engaged in discussion.

Not surprisingly, the first thing we had to establish was the frequency of the meetings and the projected time commitment. Time was scarce for the teachers, and they needed a clear picture of how the lesson study would fit into their already overloaded schedules. Tom and Gladys already knew some details about lesson study from our previous individual meetings and volunteered to share this knowledge with Sid and Jane. With support from the materials I had provided for the team, Gladys and Tom took the initiative and began explaining the structure of the professional development. As Lewis (2002) asserted, “Lesson study is a simple idea. If you want to improve instruction, what could be more obvious than collaborating with fellow teachers to plan, observe, and reflect on lessons?” (p. 1). I gladly stepped back and began listening closely so that I could provide any additional details that Tom and Gladys might overlook. This support did become necessary because, as Lewis also stated, “While it may be a simple idea, lesson study is a complex process, supported by collaborative goal setting, careful data collection on student learning, and protocols that enable productive discussion of difficult issues” (p. 1). Jane still sat quietly as she listened to the explanations, and Sid skimmed through the materials in his folder, as it appeared that he was mentally evaluating the model.

Jane took the initiative to lay out the plan for Sid when he needed additional clarification on the number of lessons that every teacher would be teaching. She became

comfortable with the group and with her knowledge of its structure and requirements, and confirmed this knowledge by sharing it with Sid and the team. In contrast, it appeared that Sid's mind was racing while he weighed the value of this professional opportunity against the commitment it required from him. He sat restless, often checking the time as if there were other places he also needed to be.

The communication within the lesson study group during this introductory meeting was encouraging. Lesson study is a voluntary, teacher-driven model focused on student-centered instruction, and teachers' understanding of it is critical for its work and progress. The teachers began pulling the outline of the lesson study together using the lesson study stages in Figure 1, and turned to me only when they found a need for clarification. This confirmed that the interest in the lesson study they initially expressed was developing and that they were gradually building confidence in the theoretical model.

I directed the team toward setting ground rules for the work of the group (Chokshi & Fernandez, 2004). This process took less time than I anticipated, because the team did not elaborate on the suggested rules included in the packet (Mills College, 2007). The teachers nodded in agreement and put check marks by the suggested rules for collaborative decision making, resolving challenges, and sharing. Gladys, Jane, Tom, and Sid, being members of the same professional teaching community, had already established a level of professional connection that included similar rules. Tom summarized it for everyone when he said, "Everybody is here to work. I think this is most important."

The last part of this first meeting was a conversation about the possibility of using the lesson study model to plan mathematics instruction sensitive to the diverse student population at NSMS. This appeared to be the factor that ultimately helped Sid make a final decision to participate. As a diversity consultant of the group, Gladys took the initiative and shared personal experiences about transferring her ways of learning and knowing mathematics from her native country to her educational experiences in the United States. She shared that writing mathematical notation could be different for division, multiplication, and decimal numbers, and invited me to share my international experiences with them. She referred to mathematics textbooks that used context for problems that might not be familiar to every child in the classroom, and gave golf and baseball as examples.

Gladys' introduction to student-sensitive instruction was the last topic for this meeting. However, Sid requested that we revisit the proposed timeline and teacher load for the lesson study. Tom and Jane outlined the lesson study for him, checking with each other and verifying with me the details of their understanding. This approach to communicating the essence of lesson study in terms of group planning and preparation was consistent with the situated learning theory for adult learning and resembled a foundational step of a community of practice (Wenger, 1998). Sid asked for more time to think about joining the group, but expressed his intent to come to the next meeting.

The discussions about the lesson study process and how it would be applied extended into the second meeting. Tom, Jane, and Gladys had though about some of the details of the lesson study and came prepared with questions about the work. Tom, for

example, asked if it was necessary to develop completely new lessons. I explained that the vital component of an effective lesson study is the detailed discussion of the lesson tied to an initially determined goal; therefore, the lesson plans could be new or existing ones.

Another pressing issue for the teachers was the need for alignment between the lesson study and the pre-algebra curriculum. They could not spare any instructional time to teach an out-of-the-curriculum-sequence lesson. Gladys illustrated how this worked at NSMS:

> It depends on the [department] timeline, because with the math department here, their efforts are toward the core test at the end, and it's one of those travel things… if it's Monday, I'm in Rome. If it's February, I'm teaching [this content], so even though our students may benefit by further digging, and more exploration, if they [the lessons] are in a timeline, that might not happen, so I don't know what our next concept might be. Tom does, he has a sense of where we are headed. And they are a little bit driven by the chapters in the book, so the teachers already have a feeling where they expect to be. So that would determine where our lessons would go.

Tom also shared that he questioned the possible benefits in planning a great lesson that would not enrich students' mathematical understanding in connection with what they were currently learning. I confirmed that according to the lesson study framework, the decision about the lessons and topics was theirs to make. They thought that under such circumstances, a timeline for the lesson study work would be critical in order to have the lessons fit within the curriculum sequence throughout the trimesters.

The need for setting a timeline for lesson teaching triggered a discussion on another organizational issue: the frequency of the lesson study meetings and their scheduling. Earlier that day Sid agreed to be part of the team, but a change in his daily

plans made it impossible for him to attend the meeting. He pointed out that such changes in his schedule were not an exception, and told me that his attendance would depend on frequent timely reminders and planning on a weekly basis. The situation was similar for the other group members. It did not take long before Gladys asked if I would be willing to schedule the weekly meetings. Tom added that such an arrangement might make it more convenient for him to attend. Gladys explained that if I were in charge of the schedule, I would be able to factor my own availability in so that it was not in conflict with the suggested meeting days and times. The meeting observations were my highest priority and I had taken steps to ensure that I could attend regardless of the day or time, but I appreciated the concern. It was one sign that the team members did not think of me as an outsider to the lesson study group, and I accepted the responsibility.

Gladys then shared her understanding of the processes that accompany learning and schooling in a different country or in a language not native to the learner. She described the stress students could experience when the ways they had learned mathematics were not considered “the right way” for solving a problem. Gladys connected these differences to the need for teaching in a student-sensitive way:

> If they [the students] come from somewhere else, they may come having it [the material] in a totally different ways, the teaching needs to be open to just that other thinking, which would be culturally relevant but not as you think of it; not that they come from another country - they come from a different school culture or a different state or a different set of math rules that they’ve been following. So I think it *is* important for them [the teachers] to be open minded and considerate. Teachers tend to teach the one way that works for them and they think it’s the easiest for others, and yet so many children in class don't don’t get it, so they ought to be considering that in whatever they are doing.

Gladys mentioned that homework is another part of instruction to consider when

planning for student-sensitive teaching. Parents are often expected to play key roles in helping with homework. She believed that this role needed to be re-evaluated; alternative ways of knowing mathematics could be preventing parents helping with traditional algorithms studied by their children at school. Thus, an additional conflict between home and school might exist. Gladys suggested that if mathematics teachers consciously evaluated their students' needs and considered them when planning all aspects of their instruction, they would be able to teach in a way that was sensitive to the personal characteristics and background of their diverse learners. She enthusiastically suggested that the team plan instruction that "goes outside the box, outside the book."

According to the tentative work plan of the lesson study group, the team was ready to begin lesson planning. The lesson study was taking shape, and lesson study experts suggest that the team clearly defined a long-term research goal before the work began (Lewis, 2002). This goal should guide the lesson planning and implementation and should unite the team in their work (Stepanek et al., 2007). Tom, who had the longest mathematics teaching experience, shared his opinion that retention of mathematical knowledge for many middle school students was questionable if it was not connected to their life experiences. He thought that teachers could provide these connections: "Teachers are…leading them, guiding them, whatever you want to call it, to the direction that you want them to go." Jane and Gladys supported his view, and the group decided that their lesson study work should be focused on providing opportunities to learn mathematics by developing understanding of its meaning and applications.

The results from the three planning and teaching cycles that followed this

introduction to lesson study are described below. These descriptions are representative of the lesson study cycles, their length, and the richness and detail of the discussion that accompanied the steps in each cycle. Some lessons involved more discussion and teacher involvement than others. This was mainly due to time constraints felt by the teachers. In every account, I recreated the atmosphere, the content, and the engagement of the teachers and how they evolved and differed from lesson to lesson. The planning meetings, their dynamics, and the levels of participation also differed depending on their assignment as either a lead teacher or observer for the particular lesson. The results of this teacher collaboration preserved the authentic features and events of the lesson study cycles.

Lesson One: Fractions

The first lesson study cycle began in December 2007 and was completed at the end of January 2008. It consisted of three discussion meetings, an observed lesson, and debriefing. The meetings were scheduled during after-school hours, and the team members had a hard time coming to Tom's classroom on time. There was always the uncertainty of how long everyone should take. Gladys saw this as a significant challenge, but also found that there were not many available options to overcome it:

> I found that it was difficult to get four grown adults in the building with different schedules, to get them together so frequently, but I think that went quite well, have us to come right after school, and then being flexible on days as needed. Some schools might have built in time, but we don't really have that built up time. Every time that we have [some extra time] that is not academic time, it is taken up with a meeting… so really that was the only solution you had.

Jane explained her reasons for being tardy:

> The problem is, after school some days it's light, and some days you have kids coming and asking to help them and parents…. I have parents all the time, you know randomly, without calling, which is fine, some times you can't call, or you can just stop and say—hey I have a question about this, or I need help with that. It's part of your job, and you are going to help them, and that's what makes it hard, and some days, it's hard to plan a meeting when you never know who's got to be coming in the door, and what's going to come up.

The lesson study group began facing time-related challenges from the very beginning. During the first lesson cycle, it took about five minutes for everyone to gather. The teachers that came first would sit at the table, get a bottle of water and a snack, and chat about events that occurred at the school. It appeared that these short minutes before the meetings were good for them to take a deep breath, relax, and catch up with colleagues away from the pressing tasks of their own classrooms.

Lesson One Topic

I was in charge of the first meeting but made every attempt to gradually withdraw and not be the dominating attendee. I provided input only when asked by the teachers. I did not have to wait long for them to take initiative and guide the lesson planning. As soon as everyone sat around the table, Tom began sharing his suggestions for a first lesson and his rationale. Tom demonstrated understanding of the structure of the lesson study, and this was one step toward teacher ownership of the process (Wiburg & Brown, 2007). He understood that the teachers were in the driver's seat now and modeled this for the rest of the group. He referred to the goal of the lesson study, and he guided the group toward a decision about a topic for the first lesson. It was obvious that Tom had thought about possible content that was both challenging for the students and part of the curriculum sequence because he immediately suggested, "Dealing with fractions, ratios,

and proportions…has always been a struggle," and continued in his specific, broken-up way of speaking: "Kids…by eighth grade, students are expected to know them…to know that…decimals and fractions…and proportions are all the same…represent the same… but they do not. They don't understand them."

Sid and Jane nodded in agreement, considering Tom's statement, while Gladys added, "They [the students] don't know how to explain them, or what they mean, [they cannot] tell a story and describe what they mean, to compare…" Sid and Gladys shared experiences that illustrated the students' struggle with ratios and proportions, while Jane sat listening attentively. She had her notebook open and occasionally wrote down notes on what her colleagues were saying. Although she had a solid educational background in mathematics, Jane had the least teaching experience and was keeping a record of what her colleagues were sharing. She appeared a little bit overwhelmed to hear her peers confidently discussing possible relationship between students' knowledge of fractions and their ways of learning based on richer experiences. Jane's behavior at this early stage of the lesson study group and her demonstrated ways of learning were one form of apprenticeship in social context (Rogoff, 1990). The lesson study was providing her the opportunity to learn at her own pace in a non-pressuring environment and without threats to demonstrate this learning before she was ready to do so. This way of learning was also in unison with the principles of adult learning and more specifically, andragogy (Merriam, 2001b). As Jane described it:

> I am a new teacher, so I like working with the other teachers to get ideas and be able to watch other teachers teach and see how they are able to get it differently or the same as me Because it is hard to see yourself, and always know what's working…so it helps to see what really works, what does not, and how other

teachers do it. And get new ideas.

Thinking about teaching ratios in ways that might be engaging to students, Tom suggested that the group use a clip from a movie, possibly “Honey, I Shrunk the Kids” (Cox, 1989), to illustrate the concept and develop a lesson around it. The suggestion was appealing to Sid and Jane, but Gladys interrupted them and was quick to provide a comment. She explained that many of the Hispanic/Latino students in her ESL classes were not familiar with many American movies regardless of their popularity or success. Thus, the inclusion of the movie clips might be meaningless or confusing for them because they would not have the background knowledge to situate the mathematical content. Thus, a well-planned activity that contextualizes ratios and proportions might not contribute to the learning of mathematics for the diverse learners and would not achieve its student-sensitive objectives.

Sid and Tom appeared surprised to learn that their idea for learning ratios and proportions might not be a meaningful experience for some of their students. Gladys explained that from her experience, some of the students’ learning was dependant on understanding the context before they could engage in an activity. Tom and Sid admitted that they had not previously considered the role of context as part of student-sensitive instruction because the examples they were familiar with, as far as they knew, were popular and contained relevant mathematical ideas to explore. Gladys’ comment stimulated new awareness that mathematical connections should be established in relevance to all of their students. Tom realized that planning student-sensitive lessons could be challenging:

> Having Gladys in there helps, in talking about…the Hispanic kids and…that was helpful, having Gladys in there. But it is hard to make it relevant to some of the students, it is hard, as far as culturally and this goes, it is challenging.

Tom's comment was representative of the struggle of teachers that consciously dedicate efforts to developing student-sensitive instruction (Kitchen, 2005). His positive attitude toward Gladys' participation in the lesson study suggested that teachers might benefit from connecting content experts with diversity consultants to begin the journey toward identifying and applying teaching practices sensitive to the needs of mathematics learners.

With the idea of using a movie now abandoned, the conversation shifted to other examples of classroom experiences with ratios and proportions. The discussion expanded to addition, subtraction, multiplication, and division of fractions, and the teachers faced another challenge: verbally explaining algebraic operations with fractions to their peers. These topics were discussed as natural extensions of the currently planned lesson, and they produced a number of learning experiences. Gladys was the first to admit that she has all algorithms memorized, but she cannot explain any of them or why she performs them a certain way. She shared, "I have always been able to get the right answer, and that's all I needed, but I didn't even know that the fraction bar is actually division until I began my educational program." This remark started a sharing of known methods for performing the operations with fractions, and occasionally, the teachers were challenged to explain the algorithms. For example, Tom recalled a method for dividing fractions using box models that he had seen before but had not used in a long time. He shared the idea with the team, and this led to an exploration of the process of division of fractions.

The team members quickly began drawing the model and attempting to decode its meaning by knowing the answer to the problem. Someone joked that these efforts were a type of backward design (Wiggins & McTighe, 1998).

The team members questioned their understanding of division of fractions beyond the algorithm of cross multiplication (or invert-and-multiply algorithm, Van de Walle, 2001) that they had used and mostly mastered over the years. They admitted that this procedural way of dividing fractions had been dominating their teaching. The teachers experimented with the approach suggested by Tom (named and modeled as the "common-denominator algorithm" by Van De Walle, p. 240), because he had only a distant memory of the method and could not explain it in detail. It took several examples and a heated discussion that again incorporated the conceptual understanding of fractions targeted by the teachers. Tom successfully led the team to rediscover and understand the method, and the teachers took turns explaining it to their peers to confirm their knowledge. Tom then found his notes on the method, and they became an additional stimulator for the teachers to trace their own thinking processes during the analysis of the method, better grasp its logic and sequence, and be able to explain it to each other. These actions indicate that this lesson study group acted as a community of practice (Lave & Wenger, 1991; Wenger, 1998), and utilized the tools that help adults in their learning. This discussion also suggested that the teachers were using the lesson study model as an arena for professional discussion, one broader than just the topic of one lesson. Jane said:

> I haven't thought about that, I've always showed it with actual numbers, in fraction forms. I have never drawn pictures of it, because I do not have blocks and manipulatives, that they can get out and build, so I liked it, I definitely learned that new concept. I have to keep practicing it, to be able to derive it right,

> especially the dividing and the multiplying one, they are a little bit trickier, and so…I don't know, part of me feels that that would be easier for the kids.

Jane was connecting her own learning experience with her abilities to teach the same content to the students. The lesson study allowed her to enrich her professional knowledge and in perspective, its applications in the classroom.

After experiencing the challenges of explaining and communicating the understanding of fractions, the teachers reviewed again the difficulties their students face with ratios and proportions. The team members thought that most of these challenges were most likely rooted in a lack of conceptual understanding of fractions. This conclusion did not appear to be a discovery or surprise to them. It seemed that they had framed students' troubles with applications and manipulations of ratios and proportions the same way before, but they had not addressed the problem. They had treated some of the symptoms by teaching and re-teaching the traditional algorithm. Gladys gave multiplication of fractions as one example. She said that memorizing traditional algorithms was often the only tool many students and adults had, but because they did not understand what the process meant or what the fractions represented, they were not able to apply it to real-life situations. She added that there was no meaning tagged to it, and even if they were able to recall the algorithm, they would not be able to apply it. Attempts to solve word problems that required use of fractional numbers were one demonstration of this challenge.

Tom was first to suggest that a deeper exploration of fractions should begin with fractions that represent part of a whole. They are, he reasoned, fundamental to building algebraic knowledge, and yet few students are able to demonstrate conceptual

understanding of them. Tom related developing a lesson that teaches fractions as part of a whole to the mathematics core: “The state core, it is all proportions and ratios, so teaching proportions and ratios [is important]…but even one ratio…what is it?” Sid, Jane, and Gladys agreed that work with proportions required an understanding of fractions. They decided that they would plan and teach a lesson that leads to an understanding of fractions as part of a whole.

Lesson One Development

Tom naturally became the leader, and he initiated the discussion for this first lesson. He had the most experience teaching a variety of mathematical content and observing diverse student learners and their challenges learning fractions. He shared one particular type of problem that challenged his students: “If you have three doughnuts and four people” –he asked–“ how much would each person get?” Sid was fast to provide an answer: “Three-fourths.” Gladys quickly interrupted: “How did you do it? Did you use math symbols? We do it mathematically, and we want the students to be able to do it mathematically, but what does it mean? How is it explained?” With Sid quickly putting together a drawing to illustrate his thinking process, Gladys continued: “This is like a whole new language. Does it really make sense for the children?” She added, “We need to include sharing and other vocabulary.” Sid agreed, “Yes, I see vocabulary issues here.” Tom then suggested, “We should start with hands-on actual manipulatives to share. We have to give them a problem, not a solution.”

In the discussion that followed, the teachers began brainstorming issues to address in order to deliver a student-sensitive lesson. First, they reasoned, the students needed to

understand what they were asked to do; or as Sid suggested, “they need the content literacy and the reading comprehension.” Second, they wanted students to have the hands-on experience when splitting wholes into pieces. Tom had another suggestion: “We could start with seven pizzas and seven people, but then ask them to do seven pizzas and five people. What happened and how did you do it?” Meanwhile, Sid was drawing circles and splitting them into equal pieces to demonstrate one possible way to answer Tom’s question. Prompted perhaps by Sid’s actions, Gladys proposed a third issue: “They have to demonstrate understanding in a pictorial way. With ESL kids, pictures work great.” There was a moment of doubt in her own suggestion, because she continued: “I looked in a sixth-grade classroom, and they still do a lot of pictorial to abstract…. Do you think [pictorial] is too easy [for eighth graders]?” Then, she provided stronger rationale for her suggestion: “Because this is something we do, [provide] a formula without knowing what it means practically, but we can’t have a manipulative for every situation…so pictorial is an option.”

Gladys appeared concerned that the teachers were using food and circular shapes for their examples. She saw them as restrictive for building deep understanding as part of the student-sensitive instruction. First, she suggested that the team use money to be shared equally among a number of people. She then brought in examples of manipulatives in different shapes: rectangles, squares, and tri-dimensional proportional fractional pieces she had made herself and some materials she found online on the use of manipulatives in the classroom. This acted as a trigger; the teachers immediately started thinking of and drawing examples using these new shapes. As Sid shared, “Gladys, she

has great insights on some things that I would not have even thought of." Gladys noticed that the teachers were limiting the exploration of fractions to only certain objects and took specific steps to make the mathematics teachers aware of her observations. She demonstrated one application of the discipline of noticing (Mason, 2002) when she, in her role of a diverse consultant, connected her observations with the goals of the lesson study group and took the opportunity to emphasize the importance of a variety of examples with when planning instruction sensitive to the needs of the learners.

Up to this point, the discussion was not focused on one specific activity that would achieve the goal of providing conceptual understanding of fractions. Tom, Sid, and Gladys were sharing pieces that had the potential to be part of a lesson, but there were not specific teaching and learning experiences tied to them. It seemed that the teachers wanted to mix everything they knew to provide one lesson that would be a good teaching example and ultimate learning experience. By exchanging multiple ideas for possible approaches to the lesson, the teachers were adding new tools to their own instructional toolbox, but at this point, did not seem able to focus on the 45-minute lesson on teaching fractions as a part of a whole. This development was consistent with the challenges to lesson study groups described by Chokshi and Fernandez (2004), and the desire to make the planned lesson a showcase of the best possible teaching.

Sid was the first one to notice this tendency, and he asked the group to focus on the desired outcomes from the lesson. He initiated a more structured lesson planning when he said, "I'm hearing a lot of good ideas, but how can we put them together?" Having said that, he remembered he had one more suggestion for the lesson: "But I think

we should include writing to do that." Gladys supported this suggestion, but also added another piece: "Yes, and to [ask the students to] articulate what they know."

At this point, the lesson was envisioned as students being able to read and comprehend problems that required the use of fractions, explain the meaning of these fractions verbally, draw their pictorial representation, explain fractions as part of a whole in writing, and write them using mathematical notation. The challenge now was to plan meaningful activities that would activate and use all modes of communication as envisioned by the teachers in a student-sensitive way. As a first lesson study experience, the teachers examined the lesson study model, experimented with sharing their knowledge with their peers, and became comfortable enough to admit that their ways of knowing and teaching were different. Thus, the planning process at this point resembled a web, with the students' conceptual understanding in the center and multiple teacher suggestions about how to achieve it branching out, rather than a linear lesson planning process (Kennedy, Tipps, & Johnson, 2007).

The group members reacted differently to this method of planning. Jane still silently observed and absorbed ideas. Her silence was possibly rooted in her lack of significant classroom experience. It appeared that she was considering every word the other teachers said, and was mentally comparing their suggestions with her own ways of teaching. As she explained later, she felt uncomfortable giving suggestions to her more experienced colleagues that early in the lesson study. It appeared that she needed time to weigh her experiences with theirs and then decide if they should be shared. Jane said:

> I am so new, I've been here only for a year, and I am a brand new teacher, so… and here, I just noticed that visuals are a big thing. And the hands on stuff, I do

> not have a lot of manipulatives yet, I want to get some, I just really do not know what's out there and what's effective. But what my experience is, it seems that manipulatives, and hands on stuff, and stuff where they can see it, and the visuals, everyone seems to get it no matter what culture they come from. No matters what cultures they come from, they tend to understand it better that way.

Although her previous teaching experience was with large groups of diverse students and she had experience using some student-sensitive strategies in her classroom, it seemed that by listening to her peers she was reconsidering her own teaching approaches. She began noticing the impact of student-sensitive strategies as part of mathematics teaching. She was also learning from her colleagues' experiences. That was probably one reason Jane voiced a wish for more lesson study time: "We met for like an hour, we had what seemed like a long time, but it would go by so fast, because there are all those things, and you try to figure stuff out."

> Gladys reacted to the broadness of the planning sessions differently:
> We had a brainstorming session, and then when we got together it was another brainstorming session…and then when we thought that the teacher was ready to teach the next week and felt "I have the lesson together", he was still brainstorming. And haven't yet thought through the concept. So it got muddy! A couple of the sessions that we had…it felt wasted because we were still brainstorming. And it's very difficult for two minds, three minds, four minds, to come to a consensus every time, especially in the final planning stages. In the initial brainstorming, we talked about different shapes, or what does it mean when we have four over five, as opposed to five over four, trying to visualize that. But when you are getting ready to teach it to your students, you got to have it clear in your own mind.

Gladys was concerned with the extra time Sid and Tom were spending browsing through teaching ideas that appeared not to result in resolution to their efforts. It was possible that the due to her different area of teaching expertise, the ongoing mathematical discussions were informational for her but not as professionally beneficial as they were for the rest of the team members. Gladys' reaction also reflected the influence of a two-

week long holiday break on the planning of this first lesson. It appeared that the team lost some momentum due to it, but despite her frustration with the direction of the lesson planning, Gladys continued to attend the meetings and to provide advice concerning the student-sensitive nature of the lesson.

The meeting atmosphere after the break was charged, as if the teachers had needed time to step back from their fast paced, information-packed discussion. They may have needed to weigh the value of every suggestion made within the group and decide which ones they would use in an actual lesson. The team took steps to compensate for the holiday interruption, and it seemed that they began more structured planning. First, Tom asked if Jane or Sid would like to volunteer to teach this lesson. He was not excluding the possibility of teaching it himself, but was willing to give the first choice to them. Sid immediately volunteered, and this brought relief to Jane. At this early stage of lesson study, she did not appear ready to incorporate all the new ideas the other team members were suggesting, to teach a lesson using them, and to be observed by others.

Having agreed to teach, Sid took the initiative and shared a plan for the lesson. He wanted to make it a student-centered activity: “I am all about discovering it. I don’t like telling them what to do.” He suggested that the students first provide their own definition of a fraction, and share their current understanding with their classmates and the teacher. Then, they had to split a whole (represented by a random shape, chosen from a circle, square, or rectangle) to be distributed evenly between four or five of people, and write the fraction that represents the part that one person would get. Gladys, who initially expressed support for the articulation of the existing knowledge Sid was suggesting,

objected: “I find that they get bogged down and they can’t actually discover the rule if they are not told what to do.” Sid thought for a moment and came up with a new suggestion: “But what if we did this…” - and he began drawing and explaining. “What if you create a chart, and you started out with a whole, and ask them to do this (he split a whole circle into four equal pieces), and then number every segment (he numbered the four segments 1, 2, 3, and 4 clockwise).” He continued to explain that if it was necessary to split the whole pizza between four people, then every person would get one of the segments, and students could draw this segment. If they had to determine what part of the whole everyone would get, they would need to draw one numbered segment in the numerator over the circle split in four equal pieces, so a person gets one piece out of four. If they were to write the mathematical notation, they would have to write one fourth. It even appeared that this representation included most of the elements that the teachers targeted during the brainstorming session.

This time, Gladys agreed with Sid’s suggestion, but had another thought: “We could make this a collaborative effort.” She explained that if the children worked in groups of four, they would be able to communicate their level of understanding with their peers. This, Gladys reasoned, would be helpful in articulating their understanding. As Gladys further explained, “The thinking process and the sense making is important,’ and working as a group, she believed, would stimulate them.

Gladys’ suggestion for group work was another step toward providing student-sensitive instruction. She had experience with second language learners from the alternative language program or from the after school clubs she advised, and had noticed

that working with peers had positive effects on their learning. As Gladys said, "[the group effort] challenges those who get it and those who don't."

Thinking of a way that would put students in charge of the process of splitting symmetrical pieces into equal parts of the whole, Tom and Sid led the group into another discussion. They reasoned that if the teacher presents the chart and gives the students every piece of information by filling in the parts and asking them to copy, they will end up with another teacher-centered lesson that would most likely not affect students' understanding of fractions. Sid suggested that the teacher should silently draw the pieces in the columns and ask the students to find a pattern. Sid could start by drawing one square piece, and then split the piece in four equal parts to further draw and define that each person receives one fourth of the whole. Then, he could have three circles that need to be split equally between eight people, and repeat the process to define three eights. He would continue with different shapes, until the students discover the pattern and define the rule in their groups. Then they would be asked to share the rule they discovered, until class consensus of what a fraction is could be defined and an explanation of how the fraction describes the process of splitting wholes in equal parts is provided. Sid summarized that this way of teaching would be one variation of a discover-a-relationship lesson (Cangelosi, 1996), and it would prompt students' existing knowledge and possibly recall of previous situations in which they had to engage in this type of equal sharing. In addition, they would be working with their peers, and thus would be talking, drawing, and writing mathematical fractions as part of a whole. Having listened carefully through the planning process, Jane was intrigued about this approach and was anxious to observe

it in the classroom:

> I don't think I have really seen this way of trying to explain the fractions, I mean, as a teacher and someone who understands math more. To me, that was kind of a concept that I thought people knew, but I never thought about [it this way]. Things like that in pictures and objects…. I definitely hadn't thought of how to teach it that way.

Jane felt confident in her mathematical knowledge, and she believed it was sufficient to support her ability to teach mathematics. The opportunity to work with colleagues and learn about their ways of teaching fractions enriched her understanding of different ways to teach the same concept, and it appeared that she appreciated the experience. She said:

> I like to provide my kids with as many options as possible, I like to try and show them as many ways to do it, because then they can pick the one that makes sense to them. They can see. So I do not know a lot yet, but on certain topics, if I do know a few ways to solve it, I'll try and show them those ways and then say—I do not care which way you are going to choose, just try and find the one that makes most sense to you. And as long as you do it right, I am fine with it. Just make sure that you understand that way.

The discussions supported Jane's efforts to learn better approaches to teaching and be supportive of her students' understanding and learning by teaching a variety of problem-solving methods. It was notable that after carefully listening to the fast-paced discussions and considering the lesson plan Sid outlined for the team, Jane added questions to the discussion. This change in her degree of participation probably signaled she did not have enough clarity on the ways the team was planning to deliver the lesson on fractions in a student-sensitive way. As soon as the lesson was defined in a systematic fashion, she was able to relate to the activities and ideas in it and began searching for more connections to mathematical learning. She asked if the examples would include

improper fractions and if students would be directed to reduce the fractions to lowest terms. Sid was convinced that at this point of instruction, students in his class would not be ready for these extensions and added that there would not be enough time in one class period to do it. Tom supported this decision because he believed that students needed to understand the concept first. He said, "It's hard to make fractions relevant to them in general…. It does not matter cultures, just…being math relevant…it is just the math content that is not fun." He continued:

> But if you can get them to be able to do some deep thinking and some critical thinking, that would allow us that…that thinking process will stick with them for whatever tasks they are dealing with. That's the benefit for all kids, I think, in the long run.

He concluded: "I think that if the kids understood the concepts better, really did the discovery of that, in the long run, when the CRT comes, it would pay off."

Tom considered the specific mathematical content and its challenge for the students. He believed that student-sensitive instruction would lead to long-term benefits for the pre-algebra students. He also connected these possible positive effects with the assessments of students' learning. In his assessment of the possible effects of student-sensitive instruction in several different directions, it appeared that he was building a positive attitude toward the lesson study professional development.

Jane's question about improper fractions triggered another discussion. Tom and Sid attempted to explain to each other how many pieces a person would get if they had four pizzas and three people and then three pizzas and four people. They began following the process as they expected their students to complete it, by splitting every whole piece into a number of equal pieces equal to the number of people, and then determining the

number of pieces every person get. They engaged in role-play using only words, but at the end were not sure if their answers were representing the actual initial scenario. Sid and Tom discovered that even with their expertise in mathematics and understanding of fractions, they struggled to explain their solutions. Tom exclaimed, “See? It is hard!” Sid countered, “Or is it too easy and we get messed up?” He summarized the efforts of the group by concluding, “We have to teach it in one powerful lesson.”

This last experience brought Tom back to the lesson, and he suggested, “They [the students] would have to write this out; so how would they do it?” Sid and Jane suggested that at the end Sid should ask the students to write a story problem that requires the use of fractions as equal sharing, and this task could be used as one assessment point. They thought that the students should do some writing throughout the lesson rather than only be asked to write at the end. Gladys suggested that after completing the pictorial and the mathematical representation of the sharing, the students label every example in another column of the table. They had to write the meaning of every fraction depending on the scenario. For example, for three-fourths, they could write, “three (objects) shared among four people.” The team agreed with this suggestion, and Sid completed the table he was going to use with the students (see Appendix B).

Lesson One Teaching

Although Gladys, Jane, and Tom all confirmed they would attend Sid’s teaching, at the time the second bell rang and the class officially began, only Jane and I were in the classroom. In the five-minute break between classes, teachers were supposed to monitor the hallways and it was difficult to make it to Sid’s classroom on time. At that time, Jane

was still teaching part-time in the afternoon, so she did not have the same obligations as Tom and Gladys in the mornings. This experience confirmed that time continued to challenge the lesson study experience for the teachers. She shared:

> And there's another thing, when we are observing, we would love to be there—from the very beginning, to the very end. But I noticed that we were thinking—you know what, that bell is ringing and I have to be in my classroom again. So that also disturbs the classroom, and that was a little defect, that we walked in later and then we had to go. So our personal concentration and then ability to provide the feedback is lost in the last few minutes. Maybe we can even plan to come in five minutes after the bell rings and have a place set aside for us in the room. Quietly come and sit down, and then five minutes before the bell rings we quietly file up and be gone. We wouldn't see the wrap-up, but this would actually make it more comfortable for the observer, because we are not free for the whole chunk of time. And we've got to be back out in the hallway and into our rooms ready to do something.

Gladys illustrated how teachers' multiple school commitments affect their involvement with the lesson study work in other ways then availability for meetings. The teachers struggled to make it to the classroom on time even for an observation that was happening during regular school hours. Gladys made specific suggestions about how to address this issue with the lesson study group and NSMS, and added to existing suggestions on the topic (Stepanek et al., 2007). She understood the importance of the observation, but could not sacrifice her daily responsibilities. She thought that even a shortened observation would benefit the lesson study group and its work, and it would even strengthen the professional relationship between team members:

> And you [the researcher and Jane] could stay, and see how it did happen, and then when we get together and talk about it. If we just say: "Well, I would have liked to see this," or "I guess that this happened," and the teacher might say, "I didn't do that, but that's a good follow up," or "I did do that while you were gone." And it's not so critical, because it leaves a little window…. It would have been nice to have it happen, but I am sure you did it while I was gone. And as colleagues, it leaves us open to the benefit of the doubt to their advantage.

Gladys saw the lesson study group as a team built on professionalism and trust, a team that worked to improve instruction for diverse student groups. She considered the teaching of the prepared lesson more important than an observation from all team members, and believed that after having spent significant time planning the lesson together, she could be confident in the analysis of others and its benefit for the work thereafter. This type of relationship is in the core of the lesson study model (Lewis, 2002). However, Gladys believed that by being tardy the teachers also influenced the implementation of the lesson and its effects on the students:

> One thing that I noticed and I think you saw it too, was when my students saw us [Tom and Gladys], they were like "Hi, Mrs. [Gladys]!" Immediately, that impacted the success of the lesson. Because they obviously weren't focused on the math lesson, "I am ready to do it!" They were looking around for the social aspect and my being there interrupted the flow of the lesson. If their regular teachers from another content would have suddenly appeared in my classroom, that would impact my lesson with them. It would impact their learning, and the teacher wouldn't get a true sense of what happens in the room.

Gladys realized that the lesson interruption was critical for students' engagement, and was worried that under the circumstances, the team was not getting the actual picture of the lesson application. She mentioned that the students who got distracted were the ones she knew were struggling in mathematics: "they are not ESL, but I work with them after school [in the homework club]." Gladys noticed important influences on the lesson that were not considered part of the initial lesson plan. Her observations on the effects of the student-sensitive instruction on the students in the classroom, combined with her knowledge about students, informed an aspect of lesson planning that needed attention in the future.

Sid's classroom layout made it impossible for the teachers to enter without being

noticed and possibly interrupting. The room appeared small with 24 students and four teachers in it. It resembled a complex mix between a scientific lab and a classroom. Textbooks were scattered on tables and shelves, and multiple papers were piled on the teacher's table in front of the room and on the teachers' desk in the corner. Entering Sid's classroom was a complicated task. There was a big cart with a large television set located by the door, and in order to make it into the room, one needed to pass through a labyrinth formed by a students table, the cart, and the teacher's table in the front. Sid also used the television as a display monitor for printouts of worksheets and assignments.

Sid first directed students' attention to the learning goal of the day. He wrote the student objective on the board and said, "I will be able to explain what fractions are in a new way." He asked the class to split in seven groups, and began writing examples of fractions. The students immediately formed the groups, which was a clue that they had worked in these groups before. Sid asked them to identify the parts of the fraction he wrote. This appeared to deviate from the original intention to direct the students to a discovery of what fractions represent rather than begin with fractions taken out of context and asking the students to identify their parts. Tom, however, thought that this was a good vocabulary activity to help activate the background knowledge of the students. Meant as a vocabulary review, this initial activity did not seem to create an atmosphere where the students could ask themselves about what would be coming and how they would get there. It appeared that the students were now expecting Sid to tell them what to do.

Sid then asked the students, "What do you think a fraction is?" He directed them

to talk about a possible definition in their groups, write one definition they agreed on, and be prepared to share this definition with the class. He gave them about three minutes.

The dynamics in the classroom noticeably changed once Sid asked the students to provide their own definition of fractions. The buzzing sounds from the groups quickly became louder. Some students were talking in Spanish, and the word *fracciones* was my only clue that the conversation was about fractions.

Sid provided timely warnings for the students that their discussion was about to end. After the allotted time, he began passing a microphone around the classroom. When given the microphone, some students chose to pass it to their peers. This allowed students who were not ready to speak in front of their peers to remain silent. At the same time, Gladys thought that this was not allowing the ESL students an opportunity to speak the mathematical language and communicate. She believed that that the exact approach should have been negotiated between student and teacher, and the rules determined beforehand:

> They need to somehow know that their time is coming up so that when the next time the microphone is passed to them, they can't say “pass,” they do not have the opportunity to say “pass.” That they actually have to vocalize and answer, but let them know ahead of time; let them prepare, and rehearse if they need to. But don't allow them to be silent all the time on the subject or when you think, “It’s OK, they're learning still” - maybe they're not, maybe they're taking advantage of “I don't have to get to that point so I'm not going to.”

It appeared that Gladys was expecting the mathematics teachers to use ESL strategies in their classes with language learners. As each participant confirmed, the one type of professional development relevant to equity and diversity in education they have been receiving was relevant to second language learners. Sid explained:

> We have [had professional development to address the growing diversity at the school], especially in the language arena, and vocabulary…by exploring that a little bit more, because there's this big move from the district to have a vocabulary in every lesson. And then the question is: "Ok how do I teach the kids science content vocabulary if they do not speak English?" There are ways, there are ways to teach it, and it is very pictorial and kinesthetic, where they have act it out, they are even some words association and the kid has some type of relation, so in those areas yes, with pictorial representation.

Sid recalled strategies that supported the language development of learners who were in the very early stages of their second language development. The students in this class, however, had more advanced second language skills. It appeared that Sid did not make a connection between the fact that their good conversational English might not be adequately translated into advanced academic language, and that this would negatively affect their decision to not speak in front of their peers. Tom provided one reason for this:

> We sit through a lot of professional development…and we kind of…[just listen to it] and go: "You give us all of this information, and we have no idea how are we are going to use this in math!" And so, it never gets used, it never gets practiced.

He found that even if they have had professional development relevant to the language needs of diverse learners, the teachers had hard time connecting it to mathematics teaching. Tom's observation and Gladys' statement about teachers allowing students to be silent was an indicator that more in-depth conversations in the lesson study group were needed that specifically explored the issues of language development within planning. A need also appeared to exist to build specific teacher actions relevant to language issues into the lesson plan.

The class groups' definitions of a fraction included, "top number divided by a bottom number," "has numerator and denominator," "numerator on top of a denominator," "a piece or pieces of a whole number," "not a whole number," "has a

number on top and on the bottom." The answers closely resembled the initial review of fractions led by Sid. These responses confirmed what the teachers have shared about their students' understanding of fractions. They, however, were answering specifically the question posed by Sid. If his question asked to state what a fraction represents, he might have elicited different information from the students. Sid referred to the students' definitions when he began guiding them to discover the meaning of the numerator and the denominator in a fraction.

The lesson continued as planned, and Sid told the students that they had to decide how to split a given shape into equal pieces and determine what piece of the whole every one would receive. He drew a shape and displayed it on the TV screen, and assigned a random number of people that needed to receive equal piece of it. He modeled the activity while asking the class for help. After the students confirmed that they understood the process, it was their turn to try. These guided practice tasks asked to split a shape in three or four equal pieces, the same as the number of student in every one of the class groups. They had to split the shape in a number of pieces equal to the number of people, use the number of pieces to provide a pictorial representation of the fraction, write the mathematical notation, and write a sentence that explained the meaning of the fraction.

The students began identifying the parts of the assignment as asked, and the room again filled with noise. Most students were busy trying to decide what fraction would represent the solution of the problems. Sid was walking around, working with the groups and answering student questions. When he was satisfied with their work and progress, he would demonstrate the process on the TV screen again before suggesting another shape

that the students had to split. Observations from the other team members illustrate best the difficulties that occurred in this process. Gladys described what she saw:

> Before he was about to speak, there was a dead silence, he stopped, he looked pensive, looked at his notes, and thought "How am I going to do this?" That should have happened well in advance of a lesson that his colleagues were going to observe him presenting, and that the students were going to be part of. If the students are going to have a sense of "Hey, this stuff is doable!" "I get it!" - then the teacher has to present [it like] "Hey, this is doable!" "Look! I can show you how to get it". It looked like it was confusing to the teacher. He did not know how to present it, what he was about to put down. I think he should have had his examples and his steps, and I know he looked at something, but maybe he was looking at a finished product… I don't know what he was looking at.

Jane shared impressions similar to Gladys' when she said:

> You could tell that he wasn't quite sure about it at times, so it would show with the kids too—"Oh, he is not quite sure, how am I supposed to know?" So I would hope that if I taught it, I would be more prepared, but I don't know. Sometimes I am not, you know, I am probably worst then him.

Jane and Gladys thought that the preparation of the teacher and his confidence affected the lesson. Their comments indicated that although lesson study was focused on the lesson and not on the teaching, it was impossible to separate the two because the method of teaching affected the lesson. These observations suggested that due to additional pressure, the presenting teacher should spend extra time to become even more familiar with the planned lesson. Gladys thought that this additional preparation for the teacher should be included as part of a meeting:

> Ask [you peer teachers], "If I say it this way, does it make sense to you?" He could even sound it out. "This is how I'd like to say it to the kids, does it come across to you?" "Did you miss something?" He could've used us as a sounding board for his ideas and ask, "Hey how am I going to do this?" or "I was thinking of doing this shape, does that work?"

The teachers did not engage in this type of in-depth discourse. Although the group

members decided that the lesson was ready for the classroom, they did not consider the readiness of the teacher to deliver it. This resulted in a lost connection between the lesson, the specific class, the teacher, and the expectations of the observers, and this threatened the lesson implementation.

Gladys suggested that the presenting teachers might have felt uncomfortable to go into that much detail with the team, because others could perceive it as lack of good teaching skills. Chokshi and Fernandez (2004) discussed similar drawbacks of lesson study implementation in the United States. The transition from teaching in isolation to collegial observations and critique was a great challenge for teachers. Tom shared:

> This is a very hard thing for teachers, I think it is hard in any career, when you are being evaluated by a supervisor, and told how things need to be, then it is … that's just rough, it's hard to on your self esteem, it's hard on you ego.

He also suggested that the team used what they learned from this experience to improve the work of the lesson study group:

> One thing that I think the benefit with this is, even though it is Sid who presented it…when we all took part of that, and it was kind of all of our lesson, it was not necessarily Sid on the spot, it was putting the lesson on the spot. Hopefully this was how it turned out.

Gladys and Jane struggled to admit that the lesson took this turn because the team had not discussed it in enough depth and that they played a role in the process. Tom, however, took responsibility for the events in the classroom. Gladys and Jane believed that the presenting teacher should initiate a more detailed discussion, as this was part of his responsibility. In contrast, Tom thought that it was team's obligation to foresee these type of difficulties and address them before they occur. The lesson study process assumed joint work and joint responsibility for the lesson development and teaching, and it

appeared that at this point, Tom was the one who had internalized the responsibilities.

Sid challenged the students' groups by changing the task. He gave them the pictorial fraction, and instructed them to fill in the rest of the information, such as the total number of people, the mathematical notation, and the written explanation. The students took longer on this problem, but all groups came up with a solution and shared it with Sid and the rest of the class. As Tom noted, "The discovery chart was 'right on' mathematically, and the lesson created a lot of good thinking. Higher-level questions were asked."

The last assignment for the students was to determine the amount of pizza every student would get if there were four pizzas to be shared between the 24 students currently in the classroom. While the students were working on the problem in their groups, a couple of their classmates brought in four pizzas that were to be shared by the students. The groups needed to determine the number of pieces each pizza had to be cut into, and how many pieces each student would receive. After successfully completing the task, the students received the actual number of pieces of pizza, and by that time, the bell rang and class ended.

Lesson One Debriefing

The debriefing session was an integral piece of the lesson study model for teachers to reflect on the lessons they created, taught, and observed, and provided them with opportunities to propose any changes they might consider necessary for future lesson applications. It was as an additional challenge for teachers to talk and critique their own work. Moreover, it seemed that the discussion was affected by professional and

ethical concerns because the team members were struggling to talk about the lesson without criticizing their colleague and his teaching of the lesson. An uneasy feeling settled around the table from the very moment that Sid, Gladys, and Jane entered the classroom. Tom was unable to join because he was busy with the ongoing preparation for a school activity. Two main issues surfaced as relevant to the teaching of this first lesson: the use of the group work, and teachers' confidence when presenting the lesson.

Gladys took the initiative and started the conversation. The discussion that followed was informative, but it appeared that every word was carefully weighed. First, Gladys asked Sid about any extension of the team lesson he implemented. Sid explained that when using the team lesson as reference, he directed the class discussion to the reducing of fractions to lowest terms and what that meant in practice. He used the pizza example from the lesson where the class cut every pizza in 24 pieces. Then, every student received one piece from each pizza, for four pieces out of 24. Sid asked the students to compare this amount with the equivalent fraction of one-sixth, and the students concluded that the amount of pizza is the same, but the efforts to cut and distribute it were not as great.

This interest in Sid's work allowed the conversation to move to what was observed in the classroom. Gladys was first to share her impressions and connect them to the goal for creating successful student-sensitive mathematical learning experience. She said:

> I have a thought for you…. Boys' school versus girls' school…and co-ed. In a co-ed school, technically you have an equal chance of success whether you are a boy or a girl, but often, the boys would rise to the top in math and science, and the girls seem to form a mini-school they found, in a co-ed school the girls seem to

> form a lower layer, but the same kind of girls, or the same girls, put them in a girls-only school, suddenly they raise to the top and then they'd form their own layers there. I think it is the same with the ESL kids. When I see them in a mixed class, and I got a chance to see my students in a mixed class with you, they are forming a layer, and it was when the microphone was passed around, —pass, pass…— they are not going to be talking. When I have them in an ESL only classroom, they can't form that lower layer. I have the more vocal kids, so someone is rising to the top, and they participate in a different way then they do in your room. I think that [a colleague] said that in his classroom, they can pass two times, and then the third time when it comes around, this time can't pass it, and this kind of forces them to become more vocal.

Gladys had several of Sid's pre-algebra students in her alternative language classes, and was able to compare their ways of learning in two different environments. She felt that in the mathematics lesson she observed, they were missing out on learning opportunities because of a lack of guidelines about student participation. The group work was supposed to support students' learning through interactions with peers, but instead it allowed the students to hide within the group and not attempt to demonstrate their efforts. It appeared that the lesson study team assumed that all students would be motivated when working in groups, and this proved different in the classroom.

Gladys explained that during group work, she required individual accountability from every ESL student. When she suggested including groups as part of this mathematics lesson, she assumed that the students would follow the same guidelines in Sid's classroom. Sid, however, had different group rules, and Gladys noticed that they affected the learning of the ESL students. She clarified that this single observation was not representative of the daily happenings in Sid's classroom, but felt that it was an important point to consider when implementing the lesson again:

> And it's just the cultural thing that I have noticed in my classroom, they are the layers…. It's just a thought that I had, and again, it might be different if I saw you

in more than one lesson.

The teachers were assuming that their colleagues knew and used the instructional strategies in a similar way as they did. The lesson observation and debriefing helped the team understand how their instructional ways differed. Since the application of group work was not discussed in detail, there was a mismatch between expectations and reality. This experience confirmed that in-depth discussions were fundamental to the lesson study model, and that no assumptions should be made without discussion if every participant shares the same understanding of the strategy meaning and applications.

Sid considered Gladys' comment and made a specific suggestion that would prepare students to be ready to speak and share their defections of fractions. He thought that every person in the group could be assigned a number, and then a random drawing could determine the speaker of the group. Sid understood that this method had possible drawbacks, but believed it was worth a try:

> I would say, in three minutes, as a team, get the answer for…whatever, get an answer and then I will draw a number, so you better know that [group answer]. The thing is, sometimes you draw a three, and one of two things happen: one that's not bad, person three on some team is: "Oh, I better know what we have—OK, come on!" and then another thing that is not so great is that this person, they might be like—really, 'I don't care!' It just makes it hard…. But I can see that happen. But that's where I would be headed with trying…with the spoke person.

Jane listened to Gladys' comments carefully, and nodded in agreement, but did not feel comfortable to share her opinion with the team. During the interview after the lesson, she said:

> I think with observing it, I saw a lot of my own classroom in that room, when you know you are trying to do an activity, to include…to get everybody motivated, but there's always the few that are not quite in it. You know, especially the bigger the class you have, the harder it is to walk around, and to make sure that everyone

> is on task. Because as soon as someone asks you a question you are stopped, and you are helping those kids, or that kid, and you are not being able to monitor and help anybody else, and you know you can't…with 45 minutes of class time, you won't get very far if you go through and you look at every single kid's paper, to see what they are doing and how far they are. You have to…after a question or two, you have to go back and progress with the lesson, so I did notice that there were a few kids that were not engaged with it, and they were just copying answers, and that's the thing, you are going to get a few kids that are on top of it, and those that are just getting the answers and then the others that are just copying. So I think, there's got to be you know a way to improve that, to fix that. I do not know what it is yet, but I like the idea of it. When the problems got increasingly harder, and they had the goal in mind— you know, the pizza, I mean, you can't always have food for them, it was good but you should not have to have prizes for them to do their work. But you know…I thought it was a fun lesson, to get them involved and motivated, and then there was a lot of interaction going on…but there were still the few that you…that were not quite with it.

During the meeting, she shared only one of the things she had noticed, and it appeared that this time, she saw it in more of a positive light:

> I was thinking about it too, but haven't it been interactive like that…. I don't think the kids…. They would have been like…I wouldn't they would have been as motivated, or want to do it, they would just think it wasn't fun, and if it was not making connections to real life.

The team members provided some feedback on the lesson, but they seemed to have a hard time coming up with suggestions for improving it without referring to the teacher. They were, however, very careful in wording their critique. Gladys voiced her belief of how teachers influence the lesson, and ultimately, its success:

> With the kids, when you show your personal enthusiasm…because they see you on day-to-day basis, this is how you set up and do things. When you do something differently, they are checking you out. For your enthusiasm, or for your confusion. This kind of skews how they like it or not. Because they are used to seeing you having some style. So if you are introducing something, you'll have to be equal enthusiastic about each one, so that they feel that is has any value. It can't look like you don't.

She was making every attempt not to critique Sid personally and framed her

observation in common terms, but it appeared that her position was grounded in the observed lesson presentation. According to Gladys, that behavior affected students' attitudes toward the material: "If the teacher is not sure, how could I learn it?" Gladys believed that teachers' enthusiasm and confidence strongly affected the mathematics learning of struggling students. Sid nodded in agreement, and then summarized, "Isn't that what happens for us? It all comes down to the affective domain. It does!"

It appeared that this debriefing session could have benefited from Tom's participation and his reflections the mathematical content and its connection to students' learning. In the interview after the lesson, he shared:

> I think that in that specific class, even if some of them did not understand the concept or what we were getting at, we were kind of leading down the path, and some of them were getting there and some of them weren't. But the deeper level thinking was going on and it generated a lot of deep thinking, which was…would be beneficial to them, the critical thinking skills.

It seemed that the two issues noticed by Gladys and Jane—teacher confidence and group work—masked for them any other details that were possibly affecting the implementation. At this point, the team did not consider their own planning and discussions as contributing factors, and did not take steps to create another plan that addressed the observed issues. As a result, they did not suggest re-teaching of the lesson. It appeared that they preferred to address the issues of student group work and stronger teaching appearance on their own terms, when they were to use the lesson in their classroom. This attitude confirmed the prevailing mentality of individual responsibility for one's classroom in North American schools (Glickman et al., 2007). It also demonstrated that although the teachers willingly discussed effective teaching strategies

leading to student-sensitive mathematics instruction, they struggled when they had to apply them in the classroom and then talk about their effectiveness. The teachers did not have experience observing and critiquing other's teaching, and felt uncomfortable throughout the debriefing session. It appeared that they needed more experience observing and giving specific feedback based on these observations.

This debriefing showed that the teachers could not spare any more time on this lesson. The required curriculum coverage and the time they had allotted were pressing them to move forward. The following episode concluded the debriefing. Sid, Jane, and Gladys discussed other student-sensitive teaching methods, but outside of the lesson that was just planned and observed:

Sid: How about this, simm[ilaritie]s and diff[erence]s…the biggest cognitive bang for your buck *(he quickly draws a table with four columns)*. I am going to call this think we did the pizza method, wow, pizza method *(we all laugh)* another method another, and another, another, another—to teach fractions. And this you can imagine like a blow up of the graphic organizer we used, so teach this, and over here you might have… method, how you did it, and give us an example, so after we teach this, we might come back to this type of global, kind of unit graphic organizer, and respond to this. And then we can teach fractions in another way.

Gladys: You are doing it with the same group of students, or because you had more than one class?

Sid: No, same group of students. And this is, of course, student need. Contingent on their needs. So if they get it, then no problem, look in your grade book, and you can see all the data and then move on. But if they don't, do these methods, and then, have them write down similarities and differences between all these methods of learning, and then have them write a writing sample—as you know, I have my kids writing "I think the (blank) method was the easiest way to understand fractions for a couple of reasons: write it up, and take 25 minutes. And you've gone through them all.

Gladys: And couldn't you do a 4 corners type of thing, stand in the corner of the one that represents your learning the best, or you found easiest, or you like the

most, so then they all come back…and then they talk about it…

Sid: Oh, yes! So these would be your corners?

Gladys: Yes, and then they could be—I like this one better because it had a picture, or I got it better, or…. And they justify it to each other, and from the discussion, there might be to sense that oh well, most of the class leans towards that, but isn't it good that I did this because this one works for that person? That would be a pretty visual feedback for you, and for each other. When they can see themselves.

Sid: And then…Four corners… I like that, but the classroom management would be just… oh gosh. But anyways, yes, very good point.

Gladys: Or I just thought of something else, holding four different colors, and then they have to compare with other kids, you know that from looking at their papers, what their response is, they need to get a sense of how they are with other kids, and hey, I am kind of the same as these people, or I am thinking differently, it validates it either way, but even holding up something like all of them have the red flag, and someone else has the yellow one, oh wow! I have the purple one, but I am not the only purple one in the room…I don't know.

Sid: Right, very good.

Gladys: And you wouldn't have to teach it so many times if they could draw back on their mathematical memory of how they have done it in the past… 6th grade is heavy on fractions, and you've got 8th grade kids. But they might not remember last week. So you almost have to give them the memory and then try to pull it out. And that would be very artificial. It's a pity to have to re-teach it. To be able to pull that comparison out of them. But then they already have something into their head, I've done fractions before, but this is how I've understood it when I've done it. Could you do it when you draw on how they've done fractions in the past…

Sid: Or it could be simply something like—in addition I'll explain 3 new things about fractions, three new ways of understanding fractions that I did not know previously, and actually that's what the simm[ilaritie]s and diff[erence]s model says, to have them articulate…

Jane: I asked my students to do a writing sample in my class… Last time I had my kids explain how to solve a problem by elimination, by substitution, or by graphing, then they had to compare and contrast. And give the similarities between elimination and substitution and graphing, and then what are the differences. And when they had to tell me which method they do prefer the

most and which one they do like the most and why. That kind of got them going and they talked about it…

Sid: Isn't that so different from the way I learned… I mean I still remember my high school algebra…. I mean my 9th grade algebra teacher—do it this way, if you do not do it the way the teacher showed you, it's wrong!

Jane: I do not remember learning it!

Sid: She was great…. But just the fact that we are having a discussion about helping kids have ownership and latitude and executive control, you know thinking about their thinking, it's just….

Gladys: It's different….

The teachers continued exploring possible instructional approaches that would promote the understanding of fractions beyond the lesson just taught. There was a genuine concern about students' opportunities to learn mathematics in the way most meaningful to them. The proposed activities were not revisions of the existing lesson, but were still student-sensitive approaches that considered the needs of the individual learner. Rather than scrutinizing the first lesson, the teachers looked ahead and made plans for tying this lesson with the rest of their units and future lessons that needed to be developed. They were continuously exchanging ideas and learning from each other. The debriefing session did not lead to a specific revision of the lesson and a suggestion to re-teach it. It provided an additional opportunity to expand the teachers' professional knowledge of ways to teach in a student sensitive way.

Lesson Two: Slope

The efforts to determine the topic of the second lesson began during the debriefing meeting following lesson one. Jane carefully observed the planning of the first

lesson and listened attentively to all team discussions and decisions, then asked if she could be the one to teach. The rest of the team agreed, and Jane began checking her timeline and unit plans so that the team could explore ways they could align the lesson topic with the curriculum.

Lesson Two Topic

The lesson study team members used their experiences with the length of the first cycle to decide when the second lesson would be taught. This helped narrow the possible content. Three to four weeks of planning were projected as being necessary for developing the lesson.

Jane considered this timeline and suggested that the team plan a geometry lesson, possibly one on perimeter and area with elements of measurement. She said that geometry would be the content she would be teaching at the time the team anticipated having a lesson ready to teach. Area and perimeter were a large element of the pre-algebra core curriculum. In Jane's experience, measurement concepts and units of measurement were an obstacle for many students. Gladys suggested that a student-sensitive lesson on this content should stress vocabulary and include manipulatives. Sid strongly supported her idea, and shared, "I have so many kids with no [geometry] language."

Jane again checked the departmental curriculum calendar and the school calendar and reconsidered the content she would be teaching at the time the lesson would be ready to teach. There was a school-wide activity during the week Jane initially proposed, and all team members were involved in it on different days. This meant that they would not

be able to observe the lesson. Jane suggested that the team plan teaching one week later, and developed a lesson related to linear equations instead.

The teachers began brainstorming possible lesson topics, and Tom mentioned that the concept of slope had been a challenge in his pre-algebra classes. He mentioned that according to his experiences, two components would provide opportunities for students' learning. These included "words that show they understood the way they [lines] are [sloped], and a demonstration of what it [slope] is." Gladys supported Tom's statement and added that from her experience with ESL students, development of vocabulary is the best place to start. Tom explained that in contrast with the topic of lesson one, the concept of slope is new in pre-algebra. A solid understanding of slope was important for building advanced mathematical skills. He summarized his idea for a student-sensitive lesson: "We have to do language, as many words as possible, definitions, and do it with investigation and discovery." Jane and Sid agreed, and the team began their planning of the second lesson.

Lesson Two Development

The development for this lesson at first appeared more structured and streamlined than the planning of lesson one. The teachers were confident in their own knowledge and understanding of slope and in their previous methods of teaching it. Jane proposed that the team use her set of worksheets on slope. The five-page packet included a list of key words, a definition of slope, the slope formula, graphing of lines with different slopes, and a word problem that required calculations using the slope formula. The teacher needed to model the tasks for the students. The team reviewed it, but found it too

complex for an introductory lesson. Tom suggested excluding the slope formula, and then deciding if the rest could be tied into the lesson. After more discussions, the team determined that they needed to explore other ideas in order to develop a student-sensitive lesson. Gladys strongly supported this decision, and shared that it demonstrated the power of collaborative work in lesson study:

> With this collaborative effort, the teachers have been forced to think how they teach it and consider that maybe, just presenting facts does not always help children, and try something new, so that the outcome that is really good is just thinking—"I wonder if my kids are going to get it?"

The brainstorming session that followed resulted in multiple proposals. Jane suggested including an activity that would prepare the students for the learning of slope: "I usually do a warm–up and a starter." Sid wanted to do this with visual materials: "I show videos of climbing and hiking, and ask them which one would be harder to climb. I usually show a video so they know what I am talking about." Gladys interrupted him, and suggested the students might not find a connection between the activities shown in the video and the slope:

> When they [the teachers] wanted to talk about real life situations where you would see slope, one teacher suggested a Powerpoint. That's good, they could see pictures of things, and pictures are very vivid for children, they bring back memories and things, but not all children have gone snowshoeing or skiing. We have children from the Marshal Islands that have not seen snow before…so you cannot talk to them about skiing, they have not done that yet, and talking about mountain climbing, if they have lived in a place where it is flat, then the mountains…well Texas or something…I do not know, but they would have not had these experiences, so showing them is just as good, but give them experiences that you can them pull them in common.

She suggested that students physically move objects on slanted surfaces with different slopes. Her comment was a turning point in the discussion. Tom remembered

taking one of his classes to the climbing gym at the school, and thought that every student could personally experience the different steepness of the walls and then use this experience to explore slope.

Gladys praised this experiential learning activity. She believed that having a common experience would unite the students in their learning. Jane was both intrigued and surprised by the direction of the discussion and the lesson. It seemed that she was envisioning a revision of her lesson, making it more sensitive to students' needs. Now, she was preparing to teach a completely new lesson, using activities and strategies that she had not used before. She did not even know that the school had a climbing gym, and Gladys took her for a visit so she could visualize the suggested activity. Jane thought that these experiences supplemented her ways of learning and stimulated her creativity:

> I like working together with the other teachers. I really like it. I am not a very creative person, I am more of the analytical, so I love working together and having ideas with other people, and not feeling the pressure of having to do it all by myself.

Tom continued the discussion and suggested that the students be introduced to slope, experience the climbing gym, and then continue the exploration of the concept in the classroom. Gladys supported Tom's view and advised that students should be asked to use their own words to describe their experience in the gym, and then have a class discussion using these descriptive words. Gladys expected that the sharing might activate previous experiences connected to slope. The sharing would validate students' experiences and lead to a meaningful learning. Gladys thought that all these elements would make the learning of slope a student-sensitive experience.

The group carefully listened to Gladys' suggestions. Jane agreed that they should

provide the students with opportunities to make connections, but was concerned that one 45-minute long class period would not be enough to climb in the gym, describe and share the experience, establish a connection between the climbing and slope, and explore slope. Tom had the same concern and suggested that the group split this lesson into a two-day experience. He thought that it was reasonable and necessary to spend more time when introducing a new fundamental concept. On the first day, he proposed, Jane could introduce slope in the classroom using some videos and drawings, and could talk to students about positive, negative, zero, and undefined slope. On the second day, she could take them to the climbing gym and then implement a classroom activity to connect the climbing with the slopes discussed on day one. Sid's idea was very similar, but he insisted that the students experience the climbing gym first, surmising that the experience and the possible inductive thinking should come first before building any other knowledge. He also felt that students should explain slope in their own words before being introduced to the term "slope" so that they "follow the development of language naturally."

Tom objected that the only words that the students would need to learn were "horizontal," "vertical," and the slope of these lines. Gladys supported Sid's thought that the vocabulary relevant to the concept of slope should be explained in students' own words first. Tom finally agreed with their rationale. Having the students go to the gym first, he concluded, provided a life example that required a lot of student involvement and complex thinking.

Next, the team focused on the climbing experience and how to tie it to the

exploration of slope. Jane suggested asking the students to draw the seven areas of the climbing gym and write words that described their experience of climbing on each one. Tom suggested that the students then return to the classroom and continue the vocabulary exploration. Jane should ask them to share their descriptions of the sloped walls. The team anticipated that they would use “hard,” “easy,” “up,” “down, and “vertical,” depending on the slope. Then, she should ask them why, in their opinion, the experience was illustrated by these words. The team expected to hear “slanted,” “angle,” and “slippery” depending on the experience. Jane also suggested writing the words on an overhead, so that all words shared by students are clearly visible as descriptors of the climbing experience. By including the anticipated student reactions in their discussion, the teachers followed the existing recommendation for lesson development as part of lesson study (Lewis, 2002; Stepanek et al., 2007; Wiburg & Brown, 2007). These expected student reactions allowed the teachers to search for more in-depth connections between student-sensitive mathematics teaching and students’ learning.

When planning the second day, the team agreed with Sid’s suggestion to implement a construct-a-concept activity (Cangelosi, 1996). It was familiar to Tom and Sid, but completely new to Jane. The learning of this new strategy was a challenge for her. To accommodate her need for in-depth understanding, the team completely changed the direction and the pace of the discussions. Tom was unsure how to describe the process: “Something was different with this one, I don’t know… I think that was part of it…because Jane was not quite sure how to use some of the strategies, and then us all trying to get together and meet. I do not know, it was just different, it was…” Gladys

shared her understanding of this change:

> The teacher that was going to present the lesson was feeling inadequate because this is her second year teaching the subject, and she was feeling overwhelmed because she could see that the others were so much more experienced and it seemed that they were talking over ahead. And because this process is new, the collaborative effort and then going in and teaching something, she was feeling, it seemed to be, but she was feeling like she might not do a good job not because she was focusing her lesson on the needs of the children, or trying to make it clear, but it was something that she was not really experienced in teaching. And I was thinking, with the process, I am not sure with the studies that have been done, but I am wondering if the teachers are teachers who have taught this many times before, so they are taking something they have already felt comfortable with, and then tweaking it and then looking at it in a different way.

The following episode from one of the planning sessions is one illustration of the process described by Gladys. In the previous meeting, the team outlined the strategy, and Tom and Sid gave examples of how they would use it in the lesson on slope. Jane felt confident in her understanding of the approach, and decided to apply it in her classroom. She came to this meeting with more questions. In the beginning of the meeting, only Jane and Gladys were in the classroom, and Jane was describing her efforts to develop deeper understanding of how to construct a concept with her students:

Jane: I did do something like this with my kids yesterday, with circle and circumference, and diameter and radius…umm…instead it was area, diameter, radius…you know what I am talking about…. But it wasn't as structured…. I *knew* it wasn't as structured as Sid does it, because I had the chart, I had my different things, I had a circle drawn, and other different things, and had them come up with the rule, and…you know, they got a lot of that, and "Oh, that's shaded in!" and that's the area, so I've done circumference, and I thought it was good it was a good way but I didn't think it was the most accessible because they were still a little unsure how do you get more of the collaboration in there, how do you get more of them creating it…

Gladys: So then you were just not quite sure how to do it?

Jane: Yes…

Gladys: Well now, waiting for Tom, he *is* coming in, he has a different way of doing things that might make more sense to you, and he'll also maybe say—well why don't you do it that way, and you could…

Jane: Yes, well I have to figure out what's working best for me…

Gladys: Yes, and my understanding for the way you [nods to the researcher] explained it so well from the beginning is, the idea of this collaboration is to work together on ideas, help each other, give each other support, and then say, you know what, taking this to my level, I would change it this way, but just be aware that you would make those changes, and it's really cognitively…

Jane experienced some success in the classroom and was encouraged by her students' reaction to the activity, but she was questioning her actions and constantly comparing them to her colleague's way of teaching. It appeared that she needed additional support from the team. Gladys confirmed that the experiences of the other team members were important, but guided Jane toward finding her own way to apply the strategy. Jane explained that she does not feel confident with the details.

Jane: Well, I wasn't sure how to write a lesson plan for this…and he was laughing—yeah, I don't know either…you know, I want to write examples, but the written out form that you give to a sub— ell how do you write a lesson plan on this. So…I don't know yet, if you…how do you do that. (*Laughs*)

Gladys: Well…what do you do first?

Jane: I don't know…

Gladys: What do you start with?

Jane: I don't know, that's what I struggle with…you know, you just…flat out and start like this? *(Points to the chart on the table)*

Gladys: Well, what came before this? What lessons came before this?

Jane: Well, what I thought we would… I somehow briefly introduce slope. And that's what I am not sure, how do I briefly introduce it without really going too far into it, before we go to the climbing wall. And then after the climbing wall on Thursday, then we are supposed to come back on Friday.

Gladys: Well that's how you do your lesson, saying— hey, remember yesterday, well they often do not know what day it is, but— remember yesterday, what did we do? Or when we went to the climbing wall…what did we talk about? Pill it out of *them*! Let *them* give the previous steps.

Jane: Then how do you…how do you transition from just talking about it?

Gladys: That's what we will ask this guy. *(They laugh while Tom sits at the table and puts his folder down).*

Jane shared her concern about the lesson and her uncertainties about her ability to successfully apply the teaching strategy in the classroom. She was comfortable enough to express her worries and to ask Gladys for advice. Gladys could not advise on the actual strategy because mathematics teaching was not her area of expertise, but she took the opportunity to suggest using students' experiences and background knowledge as part of the student-sensitive lesson. Gladys was relieved to be able to invite Tom into the discussion. Jane appeared hesitant to share her concerns with Tom:

Jane: Hummmm…I was…I don't have much new…

Gladys: Well I am going to sit over there, but I am still listening…if you could help her…she's doing a think aloud of her lesson, of the format, of how to make this *(shows the paper)* look like a lesson plan. And I said you would be great

Jane: Because I am still not a 100 percent comfortable and understanding how it works, so how do you…I am still trying to figure out how do you do the transition and how do you make it look like a lesson...but I am going to go and visit Sid's classroom tomorrow, and talk to him about these things.

Tom: OK

Jane: And we were just talking that on Thursday we were going to try and go to the climbing gym, so before we go into the gym I can introduce slope, talk about it a little bit, the go over there, and then when we come back on Friday, I can…. I was just talking to her (Gladys) about it, so how do you start this kind of structure…. She was saying that you could unpack their minds, when you say— well what did we do yesterday, remember yesterday we…dadada…went to the climbing wall, and kind of talk to them about slope…and the

experience…and I was just asking her how do you transition into something like this (points to the paper with her notes). How do you make it flow well and make sense…

Tom: So for your day, you are going to have some type of a starter…

Jane: And that's another thing I was wondering, how do I…do I do something like solve proportions and solve equations, or do I do some type of slope thing, as a starter that day. Even though we are just barely getting into it.

Tom: If it was me, my starter would be…. Because you talked already about slope a little bit…

Jane: Um-hum…

Tom: That would be…I don't know, you could, this is just an option, have your starter be your…hm….your write-up,

Jane: That's what I was thinking…

Tom: About the gym…

Jane: But I don't know if that would take too much time or kind of…OK

Tom: Just have them write down about... have them write their experience down…um…

Jane: And try to get them to maybe describe which wall was the hardest, or…

Tom: Not yet, I wouldn't…

Jane: Not yet?

Tom was taking time to consider every step of the activity, and it seemed that he was picturing his classroom and his students while talking about it. The depth of the student exploration suggested by Tom surprised Jane, and she appeared concerned with the time it would take. Tom added more suggestions:

Tom: I would just have them write a complete paragraph that's going to have five sentences in it, six sentences in it…you know, whatever…you do…your topic is…the climbing gym.

Jane: And they can just go with it?

Tom: And then expand, and then just…just write, write, write, write about it as much as you can…what happened there…or you might say, instead of five sentences, you could just say, you have to write for five complete…. This is hard to do… write for five whole minutes.

Jane: Yes, that what's probably…

Tom: Or write for three full minutes, write for three minutes, go! About the climbing gym. Don't stop! You know, the wall, what did you do, where did you go, what happened…. (*He imitates quick writing on the table*)

Gladys: And Tom, you know, with a five minute write up like that, every Thursday morning with the ESL kids, I know the other ESL teacher does it weekly as well, so that is not going to be a surprise for them.

Jane: So we may do the writing prompts, we do that, but it is not the quick…short… you know…

Gladys: Basically their brains are in the mood that they could come out and talk, and their voices are being heard out there…it is really good…when they do that, thank you Tom, this was really good…

Jane: Hmmmm….and you think that this should be… at about five minutes…

Gladys: Well, he said three, and this should…

Tom: Three, three…

Jane: For three to five minutes?

Gladys: I give it for five…but I do it on a content subject, like what it was today, imagine there would be no more hunger in the world.

Jane: OK

Gladys: So maybe when you are teaching the subject, three would be

Jane: OK

Gladys joined the discussion for a short time and took another opportunity to comment on how she finds the suggested activities student-sensitive. Jane welcomed her

contribution, and it appeared that the team reached consensus about the writing prompt at this time. The conversation continued, but Gladys left again because events outside of the room required her attention. Tom resumes his description of the lesson:

Tom: And you know, just to get them thinking about the gym, and then you could go to your task sheet…and Sid types these up… I don't type them up…because I just have them on a piece of paper…or I just have them go over to the board, and have them—OK, in your math journal, we have these columns, and this one is A, this one is B…. I just do A, B, C, D….

Jane: That's what I just had them do on Tuesday, when I did something like this with the circumference of the circle…

Tom: Well I do ABCD, that just helps me to keep my columns straight…because I got to remember which row is which…

Jane: Well yes, and Sid was saying…he did say to do a triangle and a star…and you just do ABCD….it doesn't matter, the biggest thing is don't give them the rule ahead of time…OK

Tom: Ummm…they are going to start seeing this more and more, you know, and if there's Sid's kids, they are going to be all over it…

Jane: Yes…and so when I did it on Tuesday, they were already recognizing it already…I know I didn't do it…. I know I did not do it just like him or, you know, as good, because I am just getting used to it…

Jane began identifying familiar elements in Tom's explanations, and was now able to compare his classroom structure with the one proposed by Sid. She was trying to find common elements in their work that she could confidently use in her lesson. She was still very critical of her ways of teaching and continued comparing them to Sid's. Tom proceeded with his explanation, still clearly stating that this was his way of teaching.

Tom: So now, you are going to have one in here, you are going to have your example, your example, and your example, and your example. Right?

Jane: Yes

Tom: And this is how I do it…. I do it a little bit…a little bit different than Sid…the same idea, but a little bit different. I give an example. And then over on my other board, once I get this down, my examples…this is how I do it most of the time, I mean there is variation with this, I'll put something else up there. I'll do one of the little pictures or whatever, I'll have a guy riding down a bike, and I'll have an arrow showing that he's…that he's going down hill…you know tatadadada… (he draws the guy going down hill and puts the arrow to show the direction), whatever…(his biker looks funny) Ok he might be skiing, and I would stick with skiing…but that's just me…for this first one…but you could do a whole bunch of these…you know, skiing…and I show them that it's downhill, and it's— OK, you have to figure out which column it goes in. Where would it go, you put it underneath there.

Jane: OK, OK…

Tom: And no talking, no talking in this time while they do this…between anybody… and anybody puts it. And then I do another one. And half of mine are pictures, and half of mine are words. So I may…I may say, you know…ummm… walking down a ramp…and I'll (slows down his speech) wal-king-do-wn-a-ramp. OK, write it in, where does it go? And I have them put down little asterisks…you know…so we do several of these….

Jane: Um-hum…

Tom: After we get those done, I have them…share with a partner…well partner up, everybody look…OK, with your partner, check your column A, B, or C, make sure you have them all in the same spot, so you are sure where they go…

Jane: OK (*very quietly*)

Tom: And again, this is how I do it, Sid may be doing it differently…so after you've done several of the…. I mean you are going to need… it depends on how many columns you have…

Jane: Um-hum….

Tom: So…

It seemed that Jane was surprised with the slow pace of the lesson Tom was describing, and she wanted to lead the students to the definition of slope and the slope formula a lot faster. Tom understood her concern, and suggested including more

examples that would promote students' understanding of slope.

Jane: And that's where…I thought….When we were talking about it last time, I thought we were saying because I have already introduced slope a little bit before the climbing gym, that in my columns I could do rise and run…and negative slope and positive slope…but I couldn't remember exactly if that's the way we had said…because we talked about leaving it…

Tom: If it was me, I would do this (points to the paper he just drew). I would do… hmm….What would you have talked about when you've done the slope?

Jane: Well usually when I introduce slope, I am talking about steepness…you know I talk about the four different types of slope…and give them examples of that…

Tom: Somewhere along the line, I always have them draw a slope mountain…and it works like this…(he draws) and we got the skier when it's flat, it's got the skier going up the hill, well I did not get much out of it… it's got the skier going down hill…and then it's got the skier when he's falling…you know, free fall, (we laugh)…right? OK. I always do…and so this is…and then, after I have introduced it and…whatever…then they have to go back through and they have to put in their positive, and then negative, and this is zero slope, and this is no slope…so if it was me…I would add rise and run on later…I would have this be your four types of slopes…positive, negative, zero, and the vertical…

Jane: So on the day when you guys would be coming in, just do positive negative and…

Tom: Just start with it. We may do rise and run depending on time. But I would start with positive, negative, vertical, and…rise and run…vertical and horizontal.

Jane: And then…. Once they understand those…you go into the rise and run part…and they'll…

Tom: After they do examples of these, right, after they've worked with their partner, and they have kind of talked about these, we go real quickly, and we go over these as a class…What did your group say goes in this column? What did your group say? Another group….What did you say goes in this column? And then in this column…(*to Sid who just came in*) I am just telling her how I do this.

Jane: If they didn't get it and then we go over…

Tom: Just really quick, yes…and then I put off to the side here, that to do by

themselves again, similar. I have them…what's similar about all these items in this column…what's similar about this one (points to the next one), what's similar about this one (points to the next one).

Jane: Um-hum

Tom: And after they have done the similar by themselves, again, they go back to their partner, think pair share kind of thing…

Tom: Think pair share, what did these items…

Jane: Oh, Oh!!!!

Tom: What did the items in column A have in similar?

Jane: OK!

Tom: Then we do the items on column B, and have them say what they have similar, what do the items in column C have in similar…. By now you have three or four in there…

Jane: Yes…

Tom: Right, what do they all have in similar. OK? And then they do think pair share again, and they go through that…and then we share some of these ideas as a class…

Jane: OK

Tom: Right?

Jane: Um-hum…

Tom: And then depending on how technical you'd want to get from here, how much you'd want to dive in this deep end, or if the kids are really getting it, or they got it quick and you want to go deeper, then you can expand here and do difference between columns, you could have them write their own conjecture…. But somewhere along the line, and normally I do mine right here, you…you guys have certainly come up with some similarities…I have them put a student example. I said, OK, these are all my examples; you put your student example.

This part of the conversation was typical for the planning of this lesson. Jane was

gradually building an understanding of Tom's structure. It seemed that she mentally compared his descriptions with the model she had already envisioned, and she was quietly confirming the steps of Tom's plan. As soon as it appeared that the two began merging, she became more enthusiastic and vocal, but still did not completely accept the suggestions. Sid came in at this point, and although Tom continued to lead the discussion, the dynamics of the meeting changed again.

Tom: OK, and your first student example *has* to be a picture.

Jane: OK

Tom: And then once they get done, I say, OK example number two for the student—and this time I want it—in words.

Sid: Dude, you are really rolling the Marzano graphic vocab[ulary] into induct and add…

Tom: So then they've done the work, and they do two examples in words, and then they go back to think pair share. And they share their examples with their partners, because everybody likes to share their idea, and shoe this cool stuff they wrote down, right?

Sid: Well I don't do it that much, but I know what you're saying…

Tom: Yeah…

Sid: There 's more ownership…for sure…

Tom: And then I go and I do a couple with the class, right?

Jane: Um-hum…

Tom: How long this will take…

Jane: You leave it up in the air…

Tom: You could be anywhere from…

Jane: But that's… that's…my biggest problem, my two pre-algebra classes…you'd

think it would be easier, because I only have like 15 or 16 kids…

Sid: But it takes forever…

Jane: But they can take…. I can't get them to do anything…

Tom: This can take from 15 minutes to 25 minutes…and I…, Depending on how many examples you put in, whatever you ask them to do differences here…

Jane: I think this is really great, my biggest struggle I think is going to be the motivation part and encouraging and trying to get them to want to participate…to come up with their own ideas, and to share…you know…and I don't know how to do that…

Sid: So…

Tom: After you feel you've done enough here, you know, Sid does more differences than I do, after you feel you've done enough, if you want to do differences, you can…I think once…. For me, once I have similarities there…

Sid: You have to kind of have to see the diff[erence]s to see the sim[ilaritie]s

Tom: Yes, once you have done student examples, I mean somewhere in there I have them do some examples, once they have that, I say, OK, now I need you to… write your conjecture. If you want to that in complete sentence, in a word, whatever, I don't care. What is your rule…

Sid: For that group…

Tom: For column A. A equals what. What is your conjecture. And that would be the end of this. And then from here, we could do more stuff for your lesson plan if you need more time.

Jane: Well… from here, do you go into giving them more problems to do? Like assignments type of stuff? Or is it…. Where do you…

Sid: Well…what's your goal? If your goal is to get them to use, apply, identify…what is that you want them…why are you doing this? What do you want them to do so they have to do this?

Jane: Well…I want them to be able to…find the slope.

Tom: But…so…

Jane: But I guess for right now, we are only doing…

Tom: We just went through a bunch of stuff…

Sid: We are just identifying…

Tom: We just went through a bunch of good vocab[ulary] here,

Jane: Um-hum…

Tom: It would be nice, I mean for me, if you had a Powerpoint, if you have one… I have one, you can get one, If you had a bunch of pictures,

Jane: I don't have a laptop, I don't think I can do that…

Tom: Well we can get you one…of where they are seeing it, they are actually seeing slope, and vertical and horizontal…and then they've got to…because you said you want them to

Jane: Well they can see pictures and then they have to write down what kind of slope that was…on a paper or something…

Tom: Yes…as far as slope is concerned, you…you got to break that down into several sections…you first one could be this (point to the drawings), and have them do problems with this, how do you want them to do that…Drill and kill,

Jane: So on the first day, when I am introducing it before we go to the climbing gym…

Tom: Not days, but your first concept…of slope is…positive negative horizontal and vertical….You second…and not on a graph, not on a…not finding it yet, not defining it as one-half or three, or whatever, your first day is the positive and negative…horizontal or no slope…and so you do several of that…this is kind of your first…. Your second concept is figuring out what the slope is from a line, you take it from a line…and figure out your slope.

Jane: Um-hummm…

Tom: Right?

Sid: I got a great worksheet…

Tom: Slope…slope…from a line.

Jane: Aha…

Tom: And then after slope from a line, and you can go, OK, well lets give you some ordered pairs…and then from ordered pairs, you go Ok, now find slope, and this is a great discovery on this one, it is, because I do not tell them any rules on that,

Jane: You have them do it…

Tom: I have them do it, they draw it out, and they find the slope, and if you gear your problem quickly enough, and you lead them, they' start doing the rise over the run and figure it all out… if you start from…. Ok that's zero, zero, and you next one is…you know…three, one, they are going to start seeing that the slope has something to do with..

Sid: These points…

Tom: Those points, and so you can really do…have them do enough of that and then ask some questions that lead because if they are not getting it, then we are… What is similar about the slope and the ordered pairs? Just put this stuff in there…

Sid: We can do a really cool discover a relationship of that…but that's if you had thought about like you state, yeah…. So can I go back here.

Tom: Yes, yes…

This conversation was a typical example of the expert/novice relationship that dominated the planning of the second lesson. Jane was in the role of a cognitive apprentice (Hansman, 2001), and she continuously negotiated her own teaching with the approaches offered by her colleagues. Gladys saw this aspect of the meetings as a great challenge for her, and questioned its value:

> I was thinking when I was going through the process, that every time we met, the experienced teachers were very happy to jump in, but their experience comes from two totally different teaching styles. So every time [Jane] was getting advice, she was feeling more and more incompetent because she could not match herself to either of them and she could not meet their two styles well. And in each of them what I saw was positive though, was when they were voicing their opinion, they were looking at what they have been looking many times before in a

> new way. And that probably is what would normally happen if you had experienced teacher teaching something they taught many times, the collaborative effort would then force them to re-think how they are doing it and then maybe try something news. For her, it all seemed new, and so then this process was not necessarily the best thing for her.

Gladys noticed that teacher's experience played a significant role in the lesson planning process. She connected Jane's struggle with her limited teaching experience. Jane confirmed that she needed more detail than her experienced peers. She made extra effort to internalize the amount of information available to her at the meetings. While her inexperience possibly slowed down the planning process, it also helped the lesson study work by making it more detailed and focused. At the same time, her colleagues believed that although overwhelming, the learning process appeared to be an experience of great value. Gladys shared:

> For having had that [lesson study] experience, she [Jane] would *never* teach any unit the same way again. She is going to force herself to stop and think is this the best way to present, am I really thinking of the children, how am I going to know if they got it…

As someone who was not directly involved in the mathematical discussion, Gladys was able to notice the influence of this collaborative experience on the teachers and their abilities to engage in student-sensitive instruction. The change was most noticeable for Jane, but was also happening for Tom and Sid. As Gladys shared, "I noticed in the discussion, [they were saying] 'I have not thought of it that way!'"

The final lesson plan was a composition of several teachers' ideas. Jane suggested that on the second day, she would begin by asking the students to recall their climbing experiences, refer to their drawings and notes, and write about them. This way, they would connect their existing experience, their vocabulary from the descriptive activity

after the climbing, and the actual lesson. Jane would then use the method described by Tom. She would draw slanted lines with different slopes and would ask the students to suggest real-life activities that might be represented by them. The students would then search for similarities in the activities, and would work to develop their own definitions of negative and positive slope. To reinforce the concept and connect the experience from the climbing gym with other real-life slope applications, the teachers decided to include a video that Tom created. It showed children and adults involved in a number of activities that included sloped surfaces. Throughout the lesson, the students would be given multiple opportunities to share their work with the class while constructing the concept, and Jane would be actively guiding the process with questions and clarifications as needed.

At this point, Sid shared his concern that the lesson activities might lead to student definitions of positive, negative, and zero slopes by exploring examples, but the slope of a vertical line was usually defined using the slope formula. The formula was not part of the lesson, and Tom suggested that the teacher contrasted the zero slope of a horizontal line with “no slope” for a vertical line. At first, Sid, Jane, and Gladys supported Tom’s proposition, but after using the “zero” and the “no slope” labels in a conversation, they found them confusing and not correctly representing the slope of a vertical line. The team could not agree how to include a slope of a vertical line as “undefined” in a construct-a-concept lesson, but there were no alternative suggestions. This issue was left open-ended with the teachers willing to observe what definitions the students would suggest. They did not take vertical lines out of the lesson either, and this

added to Jane's uncertainties on how to include it in the instructional activities.

Sid was also unsure if the teacher should intervene if the students erroneously concluded that going up on a surface corresponds to a positive slope, and going down corresponds to a negative slope. Tom offered his method of directing students' learning of positive and negative slope. He referred to the direction of reading and writing—from left to right. Sid and Jane agreed that this might be one way to explain, but there was no final unanimous decision about how it would be handled in the classroom. The teachers did not suggest any change in the lesson plan that addressed these concerns and did not reconsider teaching it using another approach than construct-a-concept.

Jane was still unsure about the specifics of the lesson, and after the issue of undefined slope was brought up, she asked for an additional meeting before the lesson was taught. The lack of consensus added more pressure on her readiness to be observed. The team agreed that an additional meeting would be beneficial to resolve any remaining issues. Jane found out that Sid was using the construct-a-concept approach in his classroom, and asked if she could observe his teaching at least once.

The last meeting requested by Jane brought more discussions, rather than a finalized lesson. The teachers decided not to include any summative assessment, only formative. They dedicated a large part of that meeting to a discussion on inductive and deductive reasoning, and how these methods apply to teaching mathematics in a student-sensitive way. This was another deviation from the lesson discussion, and it showed that the teachers needed a great deal of professional conversation. They used the lesson study meeting as one opportunity to share and learn from others. Jane, however, put the pieces

about the lesson together and was satisfied with the planning approach of the team:

> I would say that it did get better [compared to the first lesson], I mean it's different because I was the one teaching this time, and may be I paid more attention, I am not sure. But it seemed that there was yes, a little bit more structure. I keep thinking about the last time we met, we did walk through the lesson together, basically, it was what we were going to do, and that could have just been because of my inexperience. I was not sure what to do, but I thought that really helped, because when they [the other teachers] came in, it seemed that they were on the same page too. Because they knew what I was going to do, because we planned it. So that's what I felt like. When we planned Sid's, I thought that we talked a lot about it too, but I though it was a little bit harder concept maybe, with dividing thing up, and so it seemed that every time we met, we would leave a little bit unsure, you know, about how should we apply it.

The lesson plan remained unchanged after this meeting, with no decisions about how to define slope of a vertical line, or how the teachers would support the students in constructing an understanding of negative and positive slopes. It seemed that the team members were noticing pieces in the lesson that required a different instructional approach than construct-a-concept, but they were willing to wait and see what would happen in the classroom.

Lesson Two Teaching

Jane's classroom was very open and roomy. The desks were organized in groups of three, with the students facing each other and the teacher. The decoration on the walls was minimal, most likely because she shared the room with a foreign language teacher. On the first day, Jane gathered the students in the classroom, took attendance, and then reminded them about the gym experience. She took Gladys' advice from lesson one and informed the class in advance about their visit to the climbing gym and about possible visitors in the classroom. She explained the plan for the day, and directed the students to

the gym. The experience was new for her and the students, and Jane expected that this novelty might affect the lesson implementation:

> We have never left my room at all this year. So that was the first time we had gone anywhere, from my room, and done anything. So that could have been part of it, too, that they were a little anxious.

Jane's background in sports was evident when she directed the class to climb the walls in an organized and safe way, as the rules of the gym required. She provided short breaks between tries on the different walls, so that the students could rest and write down their descriptive words. Throughout the activity, the students were busy climbing or writing. Jane provided them sufficient time to complete every part of the wall, and then asked the class to try to transition from one wall to another without stepping on the floor and then describe the difference. Jane noticed that with a class any larger than the 15 students she had in this pre-algebra section, it would be a challenge to accommodate and manage without additional help in the gym The class spent about a half-hour in the gym before Jane directed them back to the classroom.

For the remaining ten minutes, the students first wrote about and then shared their experiences in the classroom. They used the words "slanted," "steep," 'sideways," "slippery," "leaning," then used complete phrases to describe it. The sharing was completed just before the bell rang. Jane was satisfied with this part of the lesson, and she said, "I was thinking about it, when I went home… and I really think it went really well." She thought it was a great way to create meaningful connections for students:

> It just seems really obvious, that if you can make it real life, and make them real, and not just on the paper, it's like, "Oh, that building has those slopes," and then you know it is going to retain, they are going to have that background knowledge and it's going to stick. A lot of kids may not have the background with slope, and

> not have that background knowledge, and not even know what the word slope means. I think that with the strategies and this way of teaching, it could be and I actually think it is, really effective when they can grasp it and they will remember that hopefully for the rest of their life, because they have something to relate to.

Gladys also found the climbing activity relevant to the lesson on slope and to the lesson study goal to create student-sensitive lessons:

> When the teacher took them to the climbing wall, she's given them the physical experience that they can tag a memory on to, but she's now have given them a common memory, that she is now going to pull on to, so nobody would feel disadvantaged—culturally, economically, socially, because they have not ever done that, but they have all done this. So I hope [the teachers] realize that this was one of the best things that she could have done, and then we can do that with them with whatever concepts they are talking about.

On day two, the day of the team observation, there were 12 students in the classroom, which, according to Jane, was an average attendance for this class. Jane gave a quick writing prompt to the students to describe their climbing experience from the previous day, and followed the lesson as outlined by the team. One girl shared, "The angles of the walls make it how easy it is to climb." Jane drew a table with four columns on the overhead, and drew differently sloped surfaces in the second row but left the first row empty. She asked the students to suggest activities that describe these pictures, and directed them to write the descriptions in the third row. In the fourth row, the students drew a pictorial representation of the activity they described—mountain climbing, skateboarding on a ramp, and skiing were some suggestions from around the room. After collecting their ideas, Jane asked the students to identify features that were similar or different for each column. Then they had to define the rule for each set of boxes that included a surface with the same type of slope. Throughout this activity, Jane referred to the climbing gym experience and used the words students previously used to describe it:

hard, easy, sweaty, burning, tired. The students quickly concluded that “horizontal” and “vertical” described two of the lines, and a couple of students used the word “slope” when describing the ski activity. There was disagreement for a common rule for the two slanted lines. Some students described them as “going up” and “going down,” based on the direction of movement of the person they drew. Jane asked for other suggestions of possible activities that might include slanted surfaces, and the students included an airplane taking off and landing, and kite flying as two possibilities. The students again searched for similarities in the examples, and the class agreed that the common element is either “up” or “down.”

Jane then played Tom’s video of activities that include slope. She asked the class for more examples and ideas. Then Sid, who was carefully listening to the students, challenged their examples when he asked, “But what if the hill is still like that (pointing at a line going up from left to write) and the person is going down?” This question caught Jane unprepared to handle the comments and the questions from the students. She later commented:

> And I was not sure where he was trying to get at…. I knew where he was getting at, but I was not sure what he wanted me to do with it. I was not quite sure, are you telling me to tell them, or what? So I did not tell them, because…. That made me a little nervous, because I was trying to show the example he was saying, but I was not sure if he wanted me to say—look, it’s from left to right, or how far did he want me to go. And then he mentioned, what if the person was going down the mountain? He mentioned that too. Again, I was not sure, are you trying to tell me to tell them, is that what you are asking me to do? It was fine, it was a good experience. I definitely want some feedback from them. But I was *so* nervous yesterday and today, because I just…. I know I am a new teacher, and new to this concept, and just trying to figure it out, what works for the best, and what is the most effective…

Jane had been ready to teach her students the rule of positive and negative slope,

and that would have been the approach if it were her lesson. Now she was not sure when it would be most appropriate to do that:

> Tom said it would be fine if they just look at it and when they look across the page from left to right, if it is going up, it is positive slope, if it is going down across the page, it is negative. And that's how I taught it before, but again, I was not sure how much to tell them, and what should I not, and I…

Sid's question divided students' opinions about similarities between the columns. Jane continued to respond to the questions and to take suggestions from the students, but now appeared unsure how much she should intervene and when:

> I was not sure with that model, because you are supposed to help, but here they are supposed to get it themselves and construct it…. I don't know how much to tell them and not tell them. So I did not tell them to think of it from left to right, because I am like—are they supposed to figure that out? Do I tell them—so you know I was not sure should I tell them the left to right thing, how could I better help that last little part. What I think is most of them did get it…. I think most of them got it, but I think there is still that confusion of—if you are going up the mountain, what if you turn around and go down the mountain on that same side, it is still positive.

Looking at the time she had left, Jane started using the words "positive" and "negative" when describing some of the examples. Some students also began using them. Jane asked these students to share their definitions with the class, and included few more examples to find out if the rest of the students understood the connection between positive and negative slope and the direction of the slanted line. After observing this concluding activity, Tom noticed: "Students were following the examples and giving answers back, sharing as a class."

Regardless of the uncertainty in the ways the lesson unfolded, Jane was impressed with the participation of her students during the discussion:

> The student that was sitting right here, I was blown away about how interested he

> was and how well he got it! And maybe it is bad to say and it is a stereotype, but I mean I was just not expecting it because the rest of the year, he has not been as involved, and he is not here as consistently, and so the fact that he caught on so quickly and he was so into it, and I thought it was really good.

Jane noticed that the lesson led to improved student participation and engagement. The students were comfortable asking questions and sharing opinions. Jane also observed that the construct-a-concept format of the lesson allowed her to communicate more with the individual students. This opportunity drew her attention to issues that were limiting her students in their learning of mathematics. She described one happening in the classroom:

> When I was saying similar, tell me what is similar with them, I have another student…he was asking, "but what do you mean by it?" He called me over and he asked me—what do you mean by similar? And the girl sitting next to him was like, he does not know what you mean by that. And I said, "Oh, what do they have in common." And he said "Oh, that's what you want? What they have in common?" So it kind of...this kind of hit me, when I was talking about it, [some students] are not understanding a lot of the word we use, all the time, so slope or similar, they do not always know what these are. So we have to cover it and figure out a way and make sure that they know and they understand what we are saying. And he knew, he understood the word common.

Jane had some experience teaching English language learners with very limited language proficiency. This time, she noticed that the basic communication skills of the student masked the possibility that he might not understand words used to describe everyday events. Jane had not experienced the ESL professional development the other teachers had in the past, but this episode was a great learning opportunity. If she were to teach mathematics so that every student in the classroom would understand in the future, Jane needed to make sure the students understood both the English language and the English mathematical vocabulary, and that required additional attention.

Lesson Two Debriefing

The debriefing of this lesson was individual and informal, and teachers exchanged opinions outside of an official lesson study meeting. Every team member stated that the gym activity made a difference in the students' attitudes toward the lesson, and it provided the teacher with a common reference point when discussing slope. They all planned to implement this piece of the lesson as planned and taught.

For the second part of the lesson, the team members were still uncertain about appropriate ways for leading students to define positive, negative, and undefined slope. Jane shared her doubts with Sid:

> I talked with Sid right after class, for a couple of minutes, and…because in the end of class they had this kind of debate [on going up and down and the slope], and I was not sure if I was supposed to help. And he said no, it was good, you want them discussing it and kind of arguing about it, in a good way, and trying to figure it out, but as a teacher you are supposed to guide them to the right answer, so I was still trying to figure out how do I do that without giving them the answer.

Jane, in rethinking the lesson again, even after talking to Sid, was not sure how to proceed from this point on:

> They all got the concept going up and going down, and flat and up and down, but I think what they didn't get was if they go on this one side of the mountain, it does not matter if you're going up or down that side, it's still positive, but on the other side, it does not matter if you are going up or down, it's still negative. And so it has to do more with the angle of, rather than up or down. I think they got the flat and up and down pretty good. So I am not at all sure how should I address it on Monday, do I just come in and tell them, or I'd give them more examples as we did today, and see if they get it on their own, and if they still are not getting it, kind of ease into it and tell them? Sid was saying maybe giving them the phrase "going up from left to right."

Sid did not have a solution to the dilemma of students defining negative and positive slope, but was willing to try to use the lesson as a springboard for his instruction

on slope:

> I am going to be doing something very similar to it tomorrow…it would be different…. What I am going to do is it is going to be construct a concept of rise and run, and positive and negative slopes. I'll try to put the two together, although I am still going to think about how am I going to do no slope and to recognize those, I might actually to step back and do that first and then do the rise and run…so that kind of got me thinking about that same standard in my own packet for this when I am teaching it…

Sid admitted that this lesson probably raised more questions than it provided answers for their efforts to teach in a student sensitive way, but shared that it prompted him to rethink his own teaching:

> I have not done a lesson on slope using construct a concept. Not in the same way. I think it is going to be much more powerful this way with those guys. The way this was set up, caused me to think a little bit differently about mine [my way of teaching slope], like not to put the cart before the horse, kind of think, and I think I have that on my mind with my class now.

Tom noticed that this planning process differed significantly from the first cycle, but saw that as a move in the right direction

> It's taken a long time to get through that [lesson], and I am not sure if the time issue is that everybody else is so busy, so that it's taken that many sessions to get done, or that process just takes a long time to get there, because it was long this time, it was longer than the first one. I think that the lesson planning itself is more important then [the teaching], having everybody coming together and develop a lesson, that's been actually [more important than] watching each other at it. That's just me; I might be off on that.

Tom put more weight on the group collaboration as a productive way to share ideas and learn from others about how to make mathematics instruction student sensitive. The lesson teaching was one way to share this collaborative experience, and he noticed that it had a positive influence on some students:

> This lesson here that was given, it was kind of a building block for them for slope. The time that Jane spent actually with the lesson was good, I think it is good to go

> slow, and build that. That was good. Hopefully they would start getting better critical thinking skills on how to do that. This type of [lesson] really helps, when we are doing something else that the drill and kill. It really helps them, it would help them learn the math but they know math. And change their attitude that little bit about it.

These mathematics teachers faced multiple challenges during the planning and teaching of this lesson, but they saw each challenge as a learning experience that had positive influences on their teaching practice. Tom also shared that he would try the lesson in his pre-algebra class: "I am going to try the exact same thing, I am going to try doing the exact same thing, and go the same route that Jane did." It appeared that this first attempt to teach an introductory lesson was the beginning of deeper professional explorations and possibly more informal discussions about teaching slope using construct-a-concept lessons. Student-sensitive lesson study was the impetus for the developing conversations.

Lesson Three: Probability

The third lesson study cycle was noticeably different than the other two. The planning sessions were short and did not include a lot of elaboration. There were several factors at work. First, the third cycle coincided with a number of school activities, which appeared to multiply by the day, and the teachers were often unable to attend planning meetings. Sid, for example, attended only one discussion meeting and the lesson teaching. Changes in schedules threatened meetings that were already confirmed throughout the cycle. Second, the atmosphere at the school and within the group changed as early as March, with testing approaching fast in April and May. The end-of-level

testing was a topic discussed by teachers in classrooms and hallways. As Jane explained, “Some teachers say, I need a good month to review before the test.” The teachers were also involved in field trips, high school orientation and registration events, and school shows. Finally, the lesson was planned using an existing activity created by Tom, and it appeared that the other team members had a difficult time discussing and possibly critiquing their colleague’s work.

Lesson Three Topic

The upcoming testing influenced the decision for a topic of this lesson. Immediately after the meeting for this lesson began, Tom opened a discussion about the questions on probability that he predicted were included in the end-of-level testing. He mentioned that one of the major difficulties for students was the distinction between experimental and theoretical probability and the concept of experimental probability being influenced by chance. Gladys shared that the wording of problems involving probability was a major obstacle for ESL students. She strongly recommended that the group use physical objects to teach probability, because, as she said, “When you ask them about the worksheet from Thursday, they are: ‘Which worksheet was it?’ but when you ask them about an activity they do, they remember.”

Tom mentioned that the unit on probability was also part of the remaining curriculum content that needed to be covered. He explained that students could not illustrate the relationship between experimental and theoretical probability because they did not get enough exposure to experiments. He proposed a lesson on experimental probability that would develop an understanding of this relationship. This time, the team

decided to use and modify a probability lesson that Tom had used multiple times with his classes.

Lesson Three Development

Similar to the decision on the lesson topic, which was made very quickly and without any objections or discussion, the lesson planning process was short. Tom shared his observation:

> I think that the planning process, and I am not sure if it was time or what, but there was more input given on the first lessons than there was on that third one. As far as the kind of the concept and what were you trying to get at, more collaborative work on the lesson together, more of that needed to happen.

He recognized the significant difference in the planning sessions, and suggested one reason for it: "Scheduling was getting hard, end of the [school] year is hard." Jane supported him:

> I think that this time around we definitely had more of the scheduling problems trying to get everyone at the same time, so that made it harder to plan, but when we were able to meet, I think it went well. I think we had copies of all the examples that Tom had done before, so we talked about it. So it was good, but you could just tell that there was the strain on the meetings and on trying to get everybody there…. I don't know if we ever had everybody there. For all the meetings for this one [lesson], I don't think we did. So…yes, it was a little harder.

Tom was going to teach this lesson, and he made every effort to attend all meetings. He brought the probability lab sheet he developed, and the team discussed ways it was student sensitive and what more they could do to make it responsive to the needs of the students in the classroom. The original lab included five probability tasks that required dice rolling, randomly choosing a block from a bag with four colors of wooden blocks, coin flipping, choosing a card from a deck of cards, and rotating a

spinner. Task one asked the students to roll a die 20 times, record the results, and explain why the experimental probability for rolling a one or a five might or might not be the same. Task two involved drawing a piece from a bag with four different colors of cubes 20 times, record the experimental probability for each color, and answer questions related to the observed events. Task three was to flip a fake coin 20 times and observe if there was a difference between the probabilities of getting the red or yellow side of the coin. Task four asked the students to draw a card from a deck, record, and explain the observed probability. For task five, the students needed to spin a spinner divided in six segments with different areas, and again record and explain the results. A copy of the probability lab task sheet is included in Appendix C.

Gladys was searching for other student-sensitive connections in the lesson, and suggested including games from different countries that involved probability in the lab. She reasoned that experimental probability is often observed in a game-like environment. She gave an example of a 200-year-old Australian game that involved flipping a coin. She cautioned that many games involved betting and this could make their demonstration in school environment problematic.

The team supported the idea for a game, as they anticipated high levels of interest and participation from the students. Tom and Jane tried the game Gladys suggested and found that it was a good illustration of experimental probability. Tom, however, thought that one or several games would take time away from explaining and demonstrating the concepts to ensure students' understanding of the goals and the rules of each game. In addition, he reasoned that most games would demonstrate experimental probability with

only a certain amount of outcomes, as in the described Australian game, where the event had two possible outcomes. The probability lab would engage the students in activities with a different number of outcomes, and thus they would gain diversified experience with experimental probability. He explained that in a lab, the students would also gain experience with other objects than coins.

Gladys supported this approach, and shared her observation that the lab activities resembled games. She also suggested that as an alternative, Tom could ask the students to develop their own game, which they would have to explain to the class. This would allow them to practice and demonstrate their language skills relevant to probability, and could further be related to theoretical probability when students are asked to explain what actually happens when you play versus what should happen in theory. Tom liked this suggestion, but reasoned that it should be a lesson taught after the students had experienced experimental probability in the probability lab.

Gladys also thought that the lab was an opportunity for students to develop and practice vocabulary related to probability. She mentioned that even if the students had heard and possibly used the words probability, chance, and outcome, it was in a context different from school-constructed lessons on probability, and that a variety of experiments would allow them to use the vocabulary in a specific context.

The team finally agreed and settled on Tom's lab lesson. The students would work in groups of two or three. Every team would complete the five stations in random order. There would be more than one station of every kind to accommodate for the students' preference. Gladys shared that by giving students an option to decide the order

of the activities, they would be given certain responsibility and choice, which is rarely observed in mathematics instruction. She summarized that this self-selected approach to teaching experimental probability, even if the choices were limited and all students were to be involved in each, naturally lends to the learning style of most kids, with hands-on activities and manipulatives. Tom also expected that by being allowed to move around and choose their stations, the students from one group would communicate with other groups and compare their results from identical activities throughout the lab.

Tom suggested that after completion of the station explorations, every group should write their outcomes for the same activity on the board and then sum up the total for the class. He wanted students to compare the experimental probability determined in their group to the one determined by other groups, then add the total for the class, compare any variance from the individual results, and suggest possible explanations for the observed similarities or differences.

There were two weeks between the last discussion meeting for this lesson and its proposed teaching day. The week that followed the meeting was spring break, and during the next week there was only one day when Tom was able to teach, but the rest of the teachers could not attend. The team decided that they needed to meet one more time before the lesson.

Tom had a great deal of interest in probability theory, and had explored several tools available online. During this last meeting, he demonstrated them to the team as one way to illustrate the convergence of theoretical and experimental probability. In addition, the mathematics department had just received Smart Boards, and Tom and Sid were

anxious to explore them as a part of their instruction. This meeting was almost completely dedicated to professional learning about the possible applications of Smart Boards in probability learning, but it did not noticeably alter the lesson plan.

Lesson Three Teaching

Tom introduced the activities to the 19 students in the class, and explained how to work with the bags of blocks and decks of cards to ensure that every event is random. He demonstrated every activity. After the students held short discussions deciding which one they would do first, they did not waste any time in getting into groups and moving to their selected stations. Some groups had definite preferences about the activities they would do first, and others chose randomly. Tom explained that his classroom management approach probably influenced the students' ability to make these decisions quickly and smoothly:

> I do not have a lot of discipline problems. A lot of these kids that were in there are huge discipline problems for other teachers. Maybe that's just because I am more relaxed and I let them talk more, maybe it is because after all you are allowing them to have an environment where they can do this type of things [move around and have a choice]. I don't know, there are buttons that are being pushed all the time, but for me is very much less stressful.

The students began completing the activities, and this time it appeared natural for the observers to move around the classroom and get a better impression of students' work. The student group members did not get distracted, since everyone else was moving around and talking. Some groups spent more time on one activity than others, and Tom also moved around to answer students' questions. The students began noticing differences in their outcomes when they compared results with other groups. Tom shared

that he believed this was the first step toward more in-depth learning: “I think that some of them, in their own teenage language, they were talking math language, but they were working among themselves, so that was definitely a [starting point].”

Sid took the opportunity to move around to observe the activities, and then shared:

> They were very engaged, very hands on…. For the kids actually to be up and moving, doing something, it was very student centered…. I would have done a little wrap up in the end…. A great way to teach the concept, and for the students to see how these things would be represented in a lab format. Getting them moving around, and using it as a way to comparing the experimental with theoretical.

As Jane envisioned doing the activity in her own classroom, using her own style of teaching, she commented:

> I like the groups, the only problem is that every time you have kids get up and moving around it is going to be more chaotic…. There was not really a way for him to check is everyone done without him just asking…. There wasn’t a way or order for him to go and check everyone’s paper and if they were actually finished on time and to keep them on task. Maybe if there was a time limit…. I think I am going to have timed stations, where everybody goes to stations, and you give them amount of time and then you have to switch. Then I can know for sure if everyone should have gone through the stations, when they are done.

These observations confirmed that the teachers planned the lesson as a team, but through observation, they gathered details that were important to their own method of teaching. It seemed that the more experienced teachers had developed their ways of monitoring and directing the activities in a relaxed classroom environment. They were giving their students an opportunity to choose, but still observed them closely. In contrast, Jane preferred structure and a different system of accountability she thought would ensure enhanced student engagement.

About 10 minutes before the end of the class period, Tom directed the groups to close the stations and asked one representative from each group to write their results for the coin activity on the board. Another student from each group was to write the results for the dice activity. The groups did not need another reminder, and the results quickly were written on the board for the class to see.

Tom asked why the groups did not all get the same probability on the coin activity, and why the probability was not half red and half yellow for every group (the class used fake coins, with red and yellow sides). Then the class added the outcomes for red and those for yellow and received a total for the class. The probability was still not equal for red and yellow. Tom again asked why there was a difference and a student's remarks completed the lesson. After a boy in the class answered Tom's question using the words "probability," "random," and "chance," another girl from the class turned to him and remarked, "Wow, do you speak math now?" Right then, the bell rang, and Tom only had time to confirm that the answer was correct and that the outcomes of an event are influenced by chance before the class hurried to the door.

Lesson Three Debriefing

There was no formal or informal debriefing session for this lesson. My multiple attempts to merge the schedules of all participants and have everyone agree on a day to meet were unsuccessful. We tentatively scheduled a day in the middle of the week that followed the teaching, but the teachers later informed me that they would not be able to attend. Every time I saw Jane in the hallway, she would ask me if an agreement for a meeting day had been reached. Tom also checked with me when we met at the school. I

continued checking with everyone, but an agreement for a day and time was never reached.

Meanwhile, I met with every participant individually for an interview and then for member checking. The more time that passed after the teaching, the less enthusiastic the teachers were when I checked their availability. After two weeks of fruitless attempts to get the team together, it appeared that the teachers considered their responsibilities to the lesson study group completed. I visited again with every one of them individually, expressed my thanks for their hard work, and left North State Middle School as a researcher. I did return about two weeks later for the end of the school year as a parent. The atmosphere was completely different compared to my previous visits, and all teachers appeared relieved that another school year was over.

CHAPTER VI

DISCUSSION

In this chapter, I present the findings of the study and discuss them in connection to corresponding theoretical perspectives. I then suggest possible implications of the study for the field of mathematics lesson study professional development. I reflect on the limitations of the study and conclude with recommendations for future research.

Summary of Findings

In this study I investigated the influence of teachers' participation in student-sensitive lesson study on learning, mathematics teaching, and classroom practices while working together with a diversity consultant. The first question answered was: How did student-sensitive lesson study affect teachers' learning about mathematics instruction for diverse student groups?

The student-sensitive lesson study provided the environment for teachers to transition from knowing about students' challenges in learning mathematics to planning and teaching in a way that better considered the individual learner. The experience stimulated in-depth mathematical conversations among teacher participants, and prompted a re-evaluation of the teachers' own existing mathematical knowledge and teaching. The diversity consultant supported the team in acknowledging and addressing the role of teacher explanations, lesson context, and students' language proficiency in teaching for understanding. The consultant focused the teachers' attention on how their pedagogical approaches communicated their expectations to the students, and emphasized

the need for consistently holding these expectations for all students.

The second question for the study was: How did teachers' participation in student sensitive lesson study influence their attitudes toward planning and delivering mathematics lessons to students from diverse backgrounds? The lesson study was a collaborative endeavor with a strong influence on teaching practices. The teachers expressed their personal and professional satisfaction and support for the collaborative format of the professional development. They reported that the student-sensitive focus of their work led to an increased awareness of issues that might be preventing their students from successful learning of mathematics.

The third question for this exploration was: What factors affected teacher's participation in and learning from this student-sensitive lesson planning and delivery? The lack of time to prepare and attend the lesson study meetings was an obstacle for the teachers throughout the study. They needed to align the lessons they prepared for the study with the curriculum, and this restricted their choice of content topics to explore. This also put additional pressure on their planning because the lesson needed to be taught during a particular week. The mathematics teachers linked their opportunities for professional learning and growth presented by the student-sensitive lesson study with the professional development climate at the school. They believed that the lesson study needed consistent support from teachers and administrators alike. Their lesson study experience was greatly affected by the climate of accountability, by the mandatory end-of-level testing, and by their influence on teachers' professional standing. As a result, although the student-sensitive lesson study was recognized as a professionally enriching

experience, it was not the teachers' top priority when other school-related responsibilities were present.

Discussion

Introduction

The lesson study group was organized as one professional development opportunity that allowed teachers to work in collaboration (Stepanek et al., 2007; Stigler & Hiebert, 1999) and create student-sensitive lessons that might positively affect the attitudes and achievement of their diverse student groups. The lesson study model (Lewis, 2002) was infused with efforts to apply the equity principle for teaching of mathematics (NCTM, 2000) by creating opportunities for learning (Flores, 2007) that lead to students' understanding of mathematics (Carpenter & Lehrer, 1999; Secada & Berman, 1999). The exploration focused on teachers' learning as reflected in their experiences. The sociocultural theory framework (Vygotsky, 1978), the theories for effective professional development (Glickman et al., 2007; Gordon, 2004; Loucks-Horsley et al., 1996), and the supporting adult learning theories (Meriam, 2001b) guided the initial examination.

Throughout the exploration, the focus on teacher learning challenged the cohesiveness of the analysis using these three lenses simultaneously. This prompted me to continue an exploration of the phenomenon. I initiated a scholarly search of the theoretical perspectives that synergized the three frameworks and represented the union of lesson study professional development, its sociocultural component, and the focus on

teacher learning. In the search, I reflected continuously on my observations and interviews with the teacher participants. The ongoing data collection and analysis confirmed that one of the major driving forces behind the teachers' learning was that the lesson study format and the presence of the diversity consultant led to *noticing* the detail in their own work and the work of others. Thus, John Mason's (2002) discipline of noticing united the three initial theoretical frameworks with the ongoing efforts of the teachers, and I continued to explore the phenomenon of teacher learning with its support. The study findings are discussed next.

The Challenge of Culturally Responsive Instruction

This study began as an effort to implement culturally responsive mathematics lesson study professional development with pre-algebra teachers at middle level. As teachers recognized the need for change in their instructional practices to meet the needs of diverse learners, a consultant for the lesson study team was envisioned to provide the guidance needed to learn and apply components of culturally responsive teaching in the mathematics lessons (Gay, 2000). During the course of the lesson study, the team members attempted to develop lessons that were responsive to their diverse learners. However, the instruction they developed was not culturally relevant because there did not exist a consensus on culture and teaching, nor on how to create culturally responsive instruction as a vehicle for student's learning as suggested by Ladson-Billings (1995b).

The teachers' inability to create culturally responsive lessons was rooted in their understanding of the diversity in their school, and their beliefs about how they would best

meet the needs of their students. The team members were reluctant to incorporate specific cultural practices in their instruction because they thought they would not be relevant to some of their diverse learners and would not lead to meaningful learning of mathematics for all. The diversity consultant was expected to guide the team in learning how these practices could be made part of mathematics teaching, but she did not possess Hispanic/Latino cultural or linguistic expertise and also believed that the instruction should target all students and therefore be addressed differently, as opposed to including a specific cultural activity.

Whiteness theory and color blindness. The direction of the teamwork as determined by the perceptions of four White lesson study team members about the diverse pre-algebra learners could be explained as a demonstration of their "Whiteness" expressed in their educational decision (Chubbuck, 2004). Marx (2006) defined Whiteness as "an amalgamation of qualities including the cultures, histories, experiences, discourses, and privileges shared by Whites" (p. 6). The teachers demonstrated this concept when they reconstructed within the lesson study group one dominating educational discourse: color blindness. Marx stated, "Color-blind language prevents Americans from openly discussing race without having their/our words infused with politics, judgment, and emotion. Indeed, this racial avoidance discourse is so common among Whites and so effective in derailing efforts to address racism, that Leonardo (2002) considers it the essence of Whiteness" (p. 16).

Haviland (2008) stated, "Given contemporary tensions about race, one might think that a White teacher would be more wary of discussing race in a racially diverse

setting. Yet White teachers in White-dominated educational settings are indeed likely to "gloss over" issues of race, racism, and White supremacy" (p. 40). While the lesson study team recognized the need for change in their instructional practice, they did not consciously acknowledge the fact that the majority of these students were Hispanic/ Latino. They preferred to use a more summative term, usually referring to "these students" and "those kids." Marx (2006) suggested that this type of discourse recreates the existing domination of Whiteness in the classroom: "Color-blind language superficially accepts diversity with the provision that it not be significantly different from the White norm and, most importantly, that it not *challenge* the White norm" (p. 17). The lesson study team did not take the steps to identify the members of the diverse student groups in their classrooms through their ethnicity, culture, or race. As a result, they were not able to extend their planned instruction beyond their existing level of understanding of diversity from a Whiteness perspective. Their actions could illustrate the statement made by Solomon, Portelli, Daniel, and Campbell (2005): "Whiteness was often constructed in academic life, the media, politics, and every day life of multiracial institutions as neutral and invisible." (p. 147). McIntyre (1997) suggested that teachers needed to make sense of their own Whiteness before becoming able to consider its influence on their instruction and the lesson study team.

While the Whiteness theory illuminated some underlying possibilities for the lesson study team members to adapt a summative, race-neutral approach toward the diverse student population in their pre-algebra classes, the teachers' decision acknowledged that the heterogeneity of the Hispanic/Latino group in their school was an

additional challenge for their efforts to plan and teach meaningful mathematics. Nasir and colleagues (2008) suggested that culturally responsive mathematics teaching might not be applicable in classrooms where the student body is ethnically heterogeneous. They support that "In considering heterogeneity and culturally relevant pedagogy, it may be more difficult in heterogeneous classrooms and communities to have a sense of the community that students come from; there may be greater differences in achievement and histories with school among the students as well as variety in issues that may need to be attended to" (p. 221). Sid, Tom, Jane, and Gladys experienced this challenge and did not include a specific cultural activity because of the heterogeneity they observed in their classes. They adopted one aspect of culturally relevant pedagogy, namely one that Nasir and colleagues describe as one possibility for addressing this heterogeneity. These scholars state that "teachers' orientation toward students is crucial—that they should hold themselves accountable for the success of all of their students, recognizing the capacity for success in each" (p. 224). In this effort, however, the teachers did not refer to their students' race or to their own Whiteness.

The mathematics teachers and the diversity consultant continued their work, but this work could not be considered culturally relevant. Rather, their efforts can best be described as attempting to provide instructional strategies and contexts sensitive to students' understanding and meaningful learning of mathematics. The team collaboration provided opportunities for increasing teachers' awareness of challenges that might be preventing their students from fuller success in the mathematics classroom. This teacher-driven, student-sensitive lesson study became the environment where teachers

reexamined their ways of teaching mathematics with a greater awareness of their students in mind.

The lesson study framework in student sensitive context. The lesson study framework of this professional development provided the collaborative teacher-driven type of environment that was in unison with the vision for effective professional development (Gordon, 2004; Loucks-Horsley et al., 1996), and with teachers' desire to work with colleagues on problems directly related to their classrooms. The model was implemented within an educational tradition different from the one dominating in Japan where lesson study originated (Stigler & Hiebert, 1999). It also differed from the strict content-oriented nature of the original by adding a student-sensitive component. The student-sensitive lesson study implementation and exploration showed that this form of lesson study as applied at NSMS had limitations.

First, this study confirmed the main challenge for lesson study in the U.S., which often seems to be the lack of built-in professional development as an integral part of teachers' schedules. Lesson study required multiple meetings for in-depth discussions plus classroom teaching and observations, and was time consuming and long-term. Added to the multiple responsibilities of the teachers in and outside of school, the meetings were not of highest priority for them. This supported existing observations of lesson study applications in the U.S. (Chokshi & Fernandez, 2004), and reiterated the need for careful revision and possible adaptation of the model to the reality of American schools. Tom and Sid proposed allotting time for teacher collaboration in the weekly schedule as part of teachers' contracts, but acknowledged that even availability of such

time would require a significant change in teachers' and administrators' understanding of teachers' responsibilities so that the time would be devoted specifically to lesson study. They observed that only when teachers and administrators began thinking of lesson study as an inseparable part of a school's culture and part of their immediate professional responsibilities, would it could become the form of sustained, beneficial professional development similar to the one developed and applied in Japan.

The lesson study model also situated the teachers as initiators and disseminators of student-sensitive instruction in the mathematics classroom. The model discussed here relied on the knowledge and experience of the diversity consultant about student-sensitive instructional practices and on the mathematical content and pedagogical knowledge of the teachers to develop and implement this type of lesson. From this perspective, the lesson study model was aligned with the theoretical frameworks for effective professional development (Loucks-Horsley et al., 1999), but was at the same time inherently limited by the lesson study structure as a teacher-only collaboration. The relative isolation of the lesson study group from other resources—for example, an outside expert on culturally responsive teaching—possibly inhibited the process of applying culturally specific activities in the mathematics instruction as initially planned.

Research Question One

The first question that guided this exploration was: How did students-sensitive lesson study affect teachers' learning about mathematics instruction for diverse student groups? The mathematics teachers joined the lesson study group after recognizing the pressing need for instructional change in their classrooms. They were at a professional

crossroad about the lack of success in positively influencing the low achievement of the diverse student groups in their pre-algebra classes. They volunteered to be part of the lesson study group hoping that through discussions with colleagues and with support from the diversity consultant, they would learn strategies and develop lessons that could support the learning of these students.

The student-sensitive focus of the study triggered a shift in teachers' attention to details that affect diverse learners' understanding of mathematics (Mason, 2002). Through their collaborative efforts, the teachers' enriched their existing instructional knowledge and their ways of communicating mathematical ideas. They found that the context of their mathematical lessons might strongly influence the levels of understanding for their students, and realized that in order to make their instruction student-sensitive, they have to revisit and sometime revise their own ways of understanding and communicating mathematics. They reassessed their understanding of the effects of language barriers on mathematics learning in other ways than lack of specific mathematical vocabulary. The lesson study team members learned how their actions in the classroom communicate their expectations to their students, and how this might shape the opportunities to learn mathematics.

Context of mathematics lessons. In the beginning of every lesson study cycle, the group meetings were brainstorming sessions where teachers demonstrated their existing collections of strategies on the topic. Tom gave ideas and supported those ideas with examples from his significant teaching experience. Sid insisted that the strategies were also research-proven, and often quoted Marzano (Marzano, Pickering, & Pollock, 2001)

and some of his nine strategies for successful learning. In order to make this learning meaningful, they wanted to have a context that was relevant but intriguing and engaging for the students. They approached the choice of context for the student-sensitive lesson with the notion that if that context were fun for the students, they would be engaged and therefore learning.

Gladys noticed that the context chosen by the teachers for the lesson on fractions was mathematically relevant but possibly not familiar to all students in the classroom. She cautioned the team that the lack of understanding of the context could limit some students' understanding of the mathematical content, and explained how this would transfer into lost opportunities to learn. The context should catch students' attention and prompt them to complete the mathematical tasks, but in order for that to happen, it should be accessible to all students. Gladys' remarks were consistent with the professional standards for teaching mathematics (NCTM, 1991) and their focus on worthwhile mathematical tasks that take in consideration the learning of diverse students.

The teachers were surprised to learn that what they had considered a popular context could actually be restricting students' opportunities to learn. They previously assumed that an entertaining piece would trigger students' interest and willingness to attend to the mathematical content. Now, they began reconsidering their suggestions for lesson context. They were constructing their own student-sensitive lessons, and context was one of their major building blocks. If they wanted to achieve student engagement with the lesson, they needed to review the placement of the instruction within a context familiar and enjoyable by the students. The mathematics teachers were starting to

develop ideas about coherence of the mathematics lessons with respect to student-sensitive teaching. Stigler and Hiebert (1999) said, “Coherence is achieved through weaving together ideas and activities” (p. 62). They suggested that a coherent lesson is one that is a “smoothly developing story” (p. 61). In the case of student-sensitive teaching, this coherence was possible by providing meaningful context to situate the lesson. The lesson study group was working toward teaching mathematics that would be understood and internalized by the students. Making a conscious connection between content and context while planning a lesson was one step in this direction.

This learning experience influenced the lesson planning processes throughout the study. A process started by Gladys’ remark became an integral part of the student-sensitive teaching efforts. When searching for appropriate context for the second lesson, the teachers could not agree on one that might be familiar to all students so they decided to create one. The wall-climbing experience supported the coherence of the mathematics lesson, but it was also a sign that the teachers were purposefully creating an environment for mathematical understanding (Hodge, 2006). For lesson three, they carefully considered the context of the probability lab tasks. They discussed and decided against inclusion of games as part of the experimental probability exploration because these games would not have provided a meaningful context for every class member. The teachers reassessed the context through the lens of teaching cohesive lessons that aimed for student understanding (Romberg & Kaput, 1999). They realized that a game would restrict the opportunities for exploring events with multiple outcomes, and that restriction might mislead the students in their understanding of experimental probability. The

teachers applied their knowledge about needed connection between context and content by searching for the most meaningful experiences for the students. Because of their participation in the lesson study, they noticed aspects of context that were relevant to their students' understanding, validated them in discussions with their peers, and engaged in refining of their practice (Mason, 2002). This careful alignment of lesson context and mathematical content was now sought as one defining characteristic of their efforts to teach in a student-sensitive way.

Teachers' mathematical knowledge. The main task of the lesson study group was to make the mathematical content of the lesson meaningful and understandable to the diverse learners in their classrooms. The teachers suggested that lack of conceptual understanding could be at the heart of their students' difficulties (Nasir et al., 2008). They decided to focus their efforts on rebuilding that understanding in a student-sensitive way. This attempt led to a different type of discovery about student-sensitive instruction, because it triggered a revision of teachers' own ways of knowing and teaching mathematics.

How teachers learned mathematics had a strong influence on their way of communicating and teaching it. They shared that their school experiences with mathematics were driven by teacher-determined procedure memorization. Their advanced studies were abstract and disconnected from real life applications familiar to middle school students. Because of the lesson study experience, the mathematics teachers began considering how they transferred their ways of knowing mathematics to their teaching. Gladys' words described this process best:

> [Teachers] can probably make individual changes [in their instruction], but doesn't it help to have done that thinking as a group? With that "How do I explain that to the kids" thing, I am glad we had those conversations, before the lesson was taught, because nobody had seem to have thought that really well. They were all like…when I am talking about a pizza, which number is on the top or on the bottom? How many pizzas or how many slices? How to explain the slices to how many people? How do I explain this dividing thing? I am so glad they got to talk this through, because you would have assumed that, when they are teaching numbers, that that was on the back of their minds. But it has not been, they were teaching numbers, not concepts. So really, to me that was one of the greatest benefits—it's getting that across, and forcing the people to do a little bit of thinking about "OK, I do teach this, but what am I teaching? What are they going to be able to understand? If I can't vocalize it, how could they?" How could they tell you what they are doing? It's not even the language of numerator and denominator; it's the language of real life dividing. If I was to say, I have four pizzas and seven people, which number is going on the top? What relationship does that number have to the real situation? I think that this was actually a wonderful thing. And would have probably happened with any concept. Take it from the concrete to the theoretical is an elementary step, but is seems like the secondary people cannot even remember the elementary step. They are so into that theory. So I am glad for the sake of the cultural relevance, that we had to force ourselves to think of the concrete. Because that's where some of our kids are. They do not understand the language of math enough to be able to just communicate on theoretical level, they really need to see something concrete.

The decisions to teach conceptual understanding meant that teachers had to be able to explain the concepts themselves. As Nasir and colleagues (2008) suggested, they needed to build a bridge between domain knowledge and everyday knowledge in order to make it understandable to the students. As soon as the in-depth discussions of the mathematical content began, the teachers were forced to start exploring the meaning behind the procedures they have mastered. This need to revisit their content knowledge and reason mathematically appeared challenging in the lesson study group, because the teachers had a certain level of mathematical expertise that provided them with a common ground and language when talking about and applying mathematics. They then had to attempt to use this expertise and dissect the concepts so their students could understand

them. They were now focusing on mathematics for teaching (Fernandez, 2005).

With Gladys' guidance, the mathematics teachers recognized that what might be considered common mathematical knowledge and representation might not be familiar to their eighth-grade pre-algebra students. The team committed their efforts to making the lesson student-sensitive by gradually leading the students toward bridging meaning and mathematical representation. As NCTM (2000) stated, "To be effective, teachers must know deeply the mathematics they are teaching and be able to draw on that knowledge with flexibility in their teaching tasks" (p. 17). In this way, the work of the lesson study group was aligned with NCTM's teaching and equity principles for school mathematics.

Teachers' efforts to verbalize and explain the mathematical concepts were complex. They had hard time stepping back from their current ways of knowing and explaining in order to discuss the concepts and not the procedures. Jane shared her frustration with her self-perceived inability to express her knowledge: "I have always been knowing it, how did I understand it? How did I [understand it] so I could teach it to them?"

The lesson study work prompted the teachers to make their mathematical knowledge explicit and to question if it made sense to themselves as well as others. They engaged in an examination of practice that sometimes took more effort than they expected; however, the teachers considered the efforts to be ultimately successful. The lesson study offered them opportunities to practice, share, and receive support in a non-judgmental, professional environment. In the discussion, they learned about possible weak points in their conceptual explanations, and with help from their peers, took steps to

improve. The lesson study group addressed the need for deeper understanding of mathematics teaching (Fernandez, 2005). Jane was candid about the need to revise one's own knowledge as much as possible in order to teach in a student-sensitive way:

> If we are unsure about something, how are we going to teach it in an effective way? Because you are going to try and avoid those traps that you don't understand, so you are going to try and teach it around that, and the way this concept is, you can't really avoid this that much. I mean they are going to hopefully stumble upon on their own, and then what are you going to do when they hit that…

This exploration of teachers' content knowledge and conceptual understanding increased their opportunities to make mathematical content accessible for their diverse learners. Tom and Sid often expanded the discussion beyond the content of the lesson as they searched to situate the planned lesson within a unit. The lesson on fractions as part of a whole, for example, was complemented quickly by a thorough exploration of methods for addition, subtraction, multiplication, and division of fractions. The teachers again engaged in fast-paced discussions where they explained, sought for alternative solutions, explored the methods, and checked if they were understood by their colleagues. These experiences were similar to mini-lessons where teachers rediscovered mathematical content through discourse (NCTM, 1991). It appeared that they were also trying to make the most of their lesson study experience and to cover more than a single topic. Their mathematical journeys took away precious time from more focused discussion on the lesson being planned, but it appeared that the teachers were preparing to create more student-sensitive lessons. They were taking advantage of both collegial advice and professional audience. Tom justified the need for these extensions when he shared his belief that the student-sensitive lessons needed to have a continuous presence

in their classrooms:

> I'd say that it [the student-sensitive lesson that was taught] needs to be followed through more on a continuous base; it needs to be brought up over and over and over again. You know from there, just to keep building on top of what had happened, not just do that once and let it drop. You need to keep building on top of that.

The student-sensitive lesson study work created opportunities to link the lessons' content with the teachers' mathematical knowledge. The experience led the teachers to explorations of their own ways of understanding and communicating mathematics. The teachers realized that these were critical for a successful student-sensitive mathematics lesson, and used the opportunity to build connections to more than the current topic.

Language. The lesson study group members acknowledged that most of their professional development had been relevant to second language development as the number of diverse learners in their classrooms gradually increased. Tom, Sid, and Gladys recalled workshops that provided them with specific teaching strategies for students with different levels of English language proficiency. The impact on the teachers, and subsequently on their teaching approaches, did not appear significant. Gladys summarized the reasons for this lack of results:

> Teachers tend to pull back the same thing: "That's too much trouble. It's too much preparation, too much pre-thought. I know how to teach it, here's how I do it, and here is how the textbook says it all. This is how I've always done it." So I haven't seen the impact that we should have seen.

Although English language learning experts like Gladys were available at the school to support the students from diverse backgrounds in their academic efforts, their work appeared limited to the ESL classroom, and without connections with the content teachers. As a result, the teachers often assumed that students with sufficient basic

language skills also had comparable academic language proficiency, and failed to connect academic difficulties with language proficiency.

Gladys provided the lesson study group with guidance consistent with the suggestions for incrementally challenging tasks for language learners (Vacca, 2000, as cited in Echevarria, Vogt, & Short, 2004). She suggested that the needed language skills could be developed through social interaction (Vygotsky, 1978) in a mathematical content. Gladys explained that when teachers allow the linguistically diverse learners to remain silent they are preventing the students from developing both their English language skills and mathematical knowledge in their most natural social environment—the mathematics classroom.

These points were not new to the teachers, but this time they consciously attempted to include them as part of the student-sensitive lessons. For example, in the lesson on slope, the students were asked to record their experience in their own words. The student vocabulary was used as a point to build on when introducing slope. In addition, she asked them to further explain why they chose the words they did, and modeled some re-phrasing. While talking about the walls that were harder to climb, for example, the students were prompted to explore with language and describe why they were harder. The goal of this exploration was to guide the students to construct the concept of slope and simultaneously develop skills to communicate the concept through language. The students were engaged in a meaningful activity and were gradually developing the concept of slope through experience and language. This approach was consistent with the Sheltered Instruction Observation Protocol (SIOP; Echevarria et al.,

2004). Gladys insisted that teachers require participation from all students depending on their language proficiency: “Don’t let them opt out, like the passing of the microphone - they could say pass, pass, and then those children did not get a chance to speak, because they were allowed not to.” Her approach to making language part of the mathematics learning of diverse student groups was consistent with Vygotky’s (1978) notion of the zone of proximal development. The team aimed for greater mathematical understanding by developing lessons that challenged their existing language skills.

High expectations for all students. The group planned its lessons together, and there was a sense of group ownership of the final product and the decisions about the classroom implementation. There was, however, one person in charge of teaching each of the three lessons. This teacher was, whether purposefully or not, brought into the spotlight when discussing the lessons. The group made joint decisions about the lesson content and the way it should be presented to the students, but the actual classroom experience depended on the teaching style of the presenter and on the organization and dynamics in their classroom.

The classrooms of the three mathematics teachers, as well as Gladys’ room, had different layouts, organization, and rules. The first lesson was taught close to the middle of the second trimester, and by then, there where certain patterns of communication between the teacher and students. They appeared to affect the lesson implementations, and as Gladys noted, some practices communicated low student expectations. Gladys described how a well-planned student-sensitive lesson might not lead to the desired student understanding because of these expectations:

> I was concerned about the lack of response [from some students]. It's a teacher trap when you ask a question and the same 2 students give the answer, and you say "Good, you've all got it." Because these 2 gave me the answer but those 2 probably got it before you walked in the door, it was basic and easy for them to understand. The ones that I saw that were maybe needing some more cultural support were the children that are ESL children that I knew were specifically receiving service they not only weren't the ones that were putting their hands up and answering; they were the ones when they had the microphone passed to them, they immediately passed it on. So when they were given an opportunity to be a voice, they would not speak. They would not speak and they did not write independently. All of the group activities showed that they were able to do what the teacher said—copy, steal, borrow from your friends, they did, they copied, stole, borrowed; they didn't think independently. So…I had a feeling that the ones that we're trying to reach the most were not reached because the voice of the two who knew what they were doing led the teacher to believe everybody got it. "Look how easy it was!"—the teacher was surprised, "I didn't think they'd get it so quickly!"—but did they get it so quickly? I don't think they did. So I'm assuming that the teacher, when he does a follow up lesson on this will draw from the experience. "Do you remember when we had the pizza?" "Oh, yes!" It's a good mental hook, but then he needs somehow to actually have individual students demonstrate that they understand and vocalize the concept. And I don' t think that the 2 examples or 3 that we did were enough for them to get to that point. So the cultural relevance would be that some kids take longer to get it and still need to be a voice even if somebody else will jump there faster then them. If you really want to make sure that they all get it then you are going to have to beat that thing to death, beyond the point where you feel like "Hey, they got it." Somehow guarantee that they got it and that they got it later on. Not just on that day when it seemed like: "I'm saying this, I can say that too". It's almost like a drill; it's not a guarantee of understanding.

Gladys' observations and conclusions were consistent with NCTM's (2000) call for equity in mathematics education. Gladys noticed that teachers were creating an opportunity for student learning; they were not expecting them to be active participants in this learning and were not providing them with clear expectations of their responsibilities. This type of teaching did not communicate high expectations to all students in the classroom (Jamal & Pitts, 2005). Gladys provided some specific suggestions for teacher actions that might help establish a classroom environment where high expectations are

held for all:

> The child's taking advantage of it, but the teacher is also allowing that situation to happen, and I don't think that they should. They should demand participation from the students on a level that the student is able to do, and how would the teacher know? When the teacher walks around he's looking at the group paper, he needs to go around and look at individual work. How is this child doing before he copies, and maybe not—Here's the problem"—and immediately turn to your group and have somebody do it and we'll just copy, but how about everybody does it first, turn around, and then compare. And if you haven't done it, you don't get to participate in the sharing. Until you've got something to share. And you could be right or wrong, but you've tried, you've attempted it, you've thought it through. So I think that that might make a difference for the individual.

The students were still expected to work in their group, but the teacher had the responsibility to provide with opportunities for learning. Setting up rules, following through to verify if these rules were allowing for students' learning, and expecting and monitoring students' work quality were how Gladys envisioned applying NCTM's principles in practice. She stressed that the social component of these expectations was also important, and described how with student-sensitive teaching, the students could support each other's learning, but only if the teacher was holding this expectation for them:

> Group the kids according to strong and weak together, around the room, mix them up a little, make them a little more uncomfortable, than they normally are for the copying, if they are not…if they are used to do this copying from your neighbor thing, put them with a different neighbor, maybe the neighbor is going to be a weak or a strong one, but let them also figure out for each other how they can… they might be a little bit more vocal. Or less. But I think that if he'd change the configuration of the classroom, the boy on the one side who was strong in the concept, if he had been matched with one from this of the classroom that was weak, they might have done more work that just seating and "I don't know what we are doing…." They were not helping each other. I think that that made a difference to their individual success, it was "I do not get it, and I do not get it either, so let's wait until we have something to from someone else." I think changing the groups might have been a good thing for that particular lesson or concept.

For Gladys, the lack of strict classroom and participation rules was a reason for the students not to engage in lessons, and distractions in the classroom were affecting the quality of their learning. She noticed that students who demonstrated the greatest need for student-sensitive mathematics lessons were prone to these distractions most, and she feared that the lack of rules was allowing them to hide in a chaotic environment and not stay focused and on task. Gladys suggested that one possible resolution to this contradiction was to assign specific roles to the students, and to let them know that their participation in a certain form would be required in the course of the lesson. Students would have to contribute to the lesson and would thus self-regulate their participation in groups even more with relaxed classroom rules. Gladys also suggested that if teachers observed their students in other classes, they would be able to see them in a different light. She reasoned that teachers might gain insights about possible changes in student classroom behavior according to the expectations teachers communicate to them. Gladys' ideas were leading the team toward an understanding that "expectations must be raised" (NCTM, 2000, p. 13).

The teachers began considering their role for student-sensitive mathematics teaching, and recognized that the way they communicated and demonstrated their expectations in the classroom was critical for active participation from the students. As teachers who were focused on providing student-sensitive lessons, they needed to start insisting on regular participation from all students, and their decisions in the classroom were to provide the environment conducive to do that. Learning about the need to establish an atmosphere of high expectation was part of the student-sensitive lesson

study, but was not immediately observable in the student-sensitive mathematics lessons in terms of change of classroom expectations.

The role of the diversity consultant. The mathematics teachers worked to apply their learning and combine the mathematical and the student-sensitive strands of the lesson study. The diversity consultant was a key figure who was expected to establish the important transitions and successful interaction of mathematical content and student-sensitive instruction. As part of the lesson study team, Gladys influenced the learning opportunities for its members.

The diversity consultant was envisioned to fulfill the role of a knowledgeable other, a traditional role in the original lesson study model. Contributions of knowledgeable others have been described as important for successful lesson study work (Wiburg & Brown, 2007). The consultant guided the teachers toward noticing and understanding the origin of some students' difficulties in learning mathematics (Mason, 2002), and further directed the teachers in establishing the student-sensitive connections in their lessons. The contributions of the diversity consultant affected the teachers' learning in two ways: first, they provided guidance about aspects of student-sensitive instruction; and second, they led to the teachers consciously accounting for existing discrepancies in mathematics teaching that were noticed, discussed with the group, and addressed in the lessons.

The inclusion of a diversity consultant was supported by the literature on lesson study (Lewis, 2002; Stepanek et al. 2007; Wiburg & Brown, 2007), but it deviated from the recommended content-specific expertise of the person involved. With no research to

back up the inclusion of a full-time consultant, Gladys' role was exploratory and, to a degree, experimental. The diversity consultant bridged the mathematical and student-sensitive components of the lesson study, created awareness of the origin of difficulties in mathematics learning for ESL and diverse student groups, and provided advice on appropriate instructional approaches that considered the individual needs of the students. Her influence on the work of the group and the learning of the mathematics teachers was carefully considered and examined.

The mathematics teachers described the guidance provided by Gladys as "valuable" and "helpful." She guided the student-sensitive aspect of the teamwork in a non-intrusive manner, and her contributions blended with the rest of the team discussions. This approach proved positive for the smooth functioning of the group. One aspect of this method of communication was that the opportunities for student-sensitive interventions were immediately recognized and addressed by Gladys. She carefully pointed out to the team possible student-sensitive asynchronies and advised for connections more relevant to the students.

The team members responded positively to this approach. Gladys' contributions made the other team members more "cognizant of the demographics in [their] classroom," and helped them with "little things like that tend to reach out better, [to] acknowledge [students'] previous knowledge, their culture, just little things like that in a reaffirming way" (interview with Sid). The student-sensitive guidance was gradual and connected to the mathematical content of all three pre-algebra lessons. Thus, it could be considered part of the efforts to gain additional expertise needed to teach effectively

mathematics to diverse student groups discussed by Flores (2008). At the same time, Gladys' feedback to and from the teachers was immediate, and if there were uncertainties, they were discussed on the spot. The inclusion of a diversity consultant as a full-time member of the team provided continuous support for the teachers' learning.

The teacher-consultant relationship and the learning opportunities that resulted from it were complex. During team discussions, the participation of the consultant was mostly one-sided, with Gladys providing comments and advice when she noticed situations that could challenge students' understanding. It was rare for the teachers to stop their conversations and ask if a certain approach made sense from the point of view of an ESL teacher or as a person with multicultural experience. This pattern suggested that the teachers had solid trust in Gladys' experience and judgment about appropriate student connections, and they expected her to intervene when needed. Her expertise was thus mostly incidental but relevant specifically to the discussed topics, and the teachers then generalized this new knowledge to their planning and teaching efforts. The learning opportunities for the teachers could have been expanded if Gladys included a summary of selected student-sensitive strategies for the lesson as part of the discussions. The teachers' learning about student-sensitive instruction could have also been enriched if after every lesson cycle, the team reviewed the particular connections included in the lesson and made them more explicit for future lesson applications. A clearer understanding of student-sensitive teaching possibly could have been reached by having separate team sessions where Gladys could focus only on these strategies. Such an arrangement, though, would have been quite similar to the outside expert-teacher dyad

found in professional development activities that have no significant influence on classroom instruction (Garet et al., 2001; Glickman et al., 2007; Gordon, 2004; Guskey, 2003; Loucks-Horsley et al., 1998). By including the diversity consultant in the planning sessions of the mathematics lessons, the lesson study was aligned with the principles for adult learning (Merriam, 2001b).

Gladys attended all but one of the lesson study group meetings. Her continuous presence as a consultant added another dimension to the processes of noticing and learning throughout the study. She noticed gaps or disjointed aspects in the instructional plans of the teachers, and she brought them to everyone's attention in a supportive and timely manner. Her contributions affected the mathematics teachers' abilities to notice details about their own practices. These intertwined, overlapping processes of noticing led to what Mason (2002) called "recognizing possibilities" (p. 94). After utilizing the advice of the diversity consultant in their planning, the lesson study group members were able to more specifically recognize and learn from additional possibilities for becoming student-sensitive mathematics teachers.

One possible restrictive feature of having a diversity consultant constantly present was that the mathematics teachers' seemed to be less motivated to look for student-sensitive connections on their own. The consultant could be considered a crutch for the teachers and their learning. Knowing that a consultant would be available for advice, the teachers might not have attempted to seek ideas in and out of the lesson study group. The continuous presence and contributions of the diversity consultant, however, might have been beneficial for the teacher participants even though it possibly prevented

them from being more proactive. With time, the teachers may have gained more confidence in their ways of finding and incorporating student-sensitive approaches in their lessons. Then, the role of the diversity consultant, including her attendance, might change. In this study, that point was not reached, and the lesson study team relied on the contributions of the consultant. However, the teachers actively responded to Gladys' suggestions and shared their own experiences. This signaled they were building the knowledge and skills needed to search for and incorporate student-sensitive instruction.

On the other side of the teacher-consultant relationship, Gladys engaged in her own ways of learning from the mathematics teachers and their ongoing discussions. She learned about the instructional practices of the mathematics teachers, which in turn sharpened her own sensitivity and competency about possible student-sensitive connections in instruction. As a full-time member of the team, she was aware of all topics, suggestions, and discussions and learned from the teachers' propositions. For example, Gladys struggled when searching for a student-sensitive connection in the lesson on slope. She was convinced that the lesson needed a common experience to build on, but could not identify a specific one that was readily accessible for the mathematics teachers. She was excited when Sid suggested taking the students to the climbing gym, and immediately reflected on this opportunity from a student-sensitive perspective. The collaborative work made this exchange of ideas possible, and pushed the work of the lesson study team ahead. In addition, it showed that the study participants actively considered all approaches suggested by the team members and were reflecting them through the prism of their own experiences.

Attitudes Toward Planning Student-Sensitive Lessons

The second research question for this investigation asked how teachers' participation in student-sensitive lesson study influenced their attitudes toward planning and delivering mathematics lessons to students from diverse backgrounds. The teachers shared their attitudes in interviews, and to preserve the authentic voice of every participant, they are presented here individually. I then summarized the attitudes shared by the lesson study group as a whole.

Tom. Tom was supportive of the student-sensitive lesson study project before it began. He was interested in working together with his colleagues and in finding ways to teach mathematics more effectively to diverse student groups. The actual lesson study experience confirmed his expectations for a collegial collaboration that provided teachers with opportunities to explore mutual professional concerns:

> I think that the idea behind it, that we get to work with other teachers and…I really liked how we sat down discussed the concept…one of the most confusing concepts the children have been struggling on, and we talked about and we worked it out and we came up with a good way to present the lesson and to help the students understand it. I think that was really beneficial. So that idea, to be able to do that, is very beneficial to teachers, to get them to do that.

Often in our conversations, Tom would mention that the lesson study is a form of professional development from which all mathematics teachers at NSMS, and all departments throughout the school, would benefit. He was supportive of the structure of the lesson study group, including its size, meeting frequency, and focus on teaching. He did, however, reflect on the model and on its student-sensitive commitment from two perspectives: a teacher's and a department chair's.

Tom's attitude toward the student-sensitive lesson study could be summarized as "positive." He was somewhat surprised that using the lesson study resulted in taking a long time to prepare even one lesson and shared, "I have never done it…to sit down with many people and gone over the lesson in *that much* detail before." Then, a few minutes later, after discussing the work of the group and its effects on teachers' practice, he shared, "I think this professional development for the math is good." He said the following after a couple more minutes of discussion:

> How this is set up, really honestly, I think if it was applied across the school, it's very flexible, people working within their departments, getting people together, giving them the time to sit down, develop good lessons, and make it relevant, concept wise and student culture wise, I think that would happen, I think it is a good model. I do.

It appeared that Tom found significant professional value in the student-sensitive professional development as demonstrated during our next conversation: "I think the collaborative part of it has got to increase." Tom was gradually noticing details in the student-sensitive lesson study (Mason, 2002) that were influencing his attitude toward this form of professional development. His statements were also supportive of the frameworks for effective professional development (Gordon, 2004), and confirmed that effective teachers seek and appreciate the opportunities for improvement (NCTM, 2000).

Tom was positive about Gladys' contributions for the team and the effects of the student-sensitive lessons on student learning. Then, when we met for an interview after the third lesson, there was some change of mind: "I am not sure if it was necessary for Gladys to be there every time, I think it was more beneficial having the other math teachers, pulling ideas together…." The gradual change in Tom's attitude followed the

progression of the student-sensitive lesson study. The first lesson was somewhat of an exploration for the team. They needed to discover the model for themselves, and to be attuned to the specifics of the lesson study work and to the student-sensitive elements in it. The second lesson was more settled, and the teachers were more confident knowing how the model functioned, having established some positions within the team. The third lesson consisted of quick decisions, with a group member absent from almost every meeting. The lesson planning coincided with the preparations for the end-of-level tests, and all teachers, including Tom, were busy with preparations and the lesson study meetings were their opportunity to share their concerns. It appeared that Tom's attitude was influenced by these developments within the lesson study group and within the school, as suggested by professional development theory (Glickman et al., 2007). Tom ultimately defined his position toward lesson study in terms of his own philosophy of teaching. He believed that building critical thinking skills and "getting them [the students] turned on to math" defined the meaningful way to teach mathematics The student-sensitive lesson study was one way for him to demonstrate his beliefs and to support them with efforts. Tom appeared to be on his way to becoming a teacher leader (NCSM, 2008; NCTM, 2000).

There were elements in the student-sensitive lesson study that concerned Tom. The length of a lesson study cycle was one of them. After the first lesson, he shared that while he learned from the long experience, the teachers each had six lessons to teach every day, not all of them on the same content, and paying that much attention to one was not very realistic. The second lesson brought a change of mind: "I think the lesson

planning itself is more important then actually watching each other at it… having everybody to come together and develop a lesson." It seemed that Tom was trying to weigh the benefits of the student-sensitive lesson study against the commitment it required. This experience was not long enough for him to decide how he felt about it. His first comment also reflects one defining element of lesson study applications in the United States (Chokshi & Fernandez, 2005). Teachers and administrators in the U.S. often search for a professional development that would bring fast, significant changes with the least investment, and the lesson study is the opposite of all these. It is a sustained, in-depth collaboration that brings gradual, but continuous improvement and requires significant commitment of resources. The lesson study required a different mindset, and although Tom demonstrated that he had discovered some of its benefits, he still had his doubts.

Tom was in a process of evaluating the student-sensitive lesson study as a professional opportunity for him. This influenced his attitude toward his own ability to develop and teach this type of lesson. His intentions to teach the student-sensitive lessons to his classes immediately were one indicator of his positive attitude toward this type of instruction and his ability to teach it. Tom found the group efforts helpful in efforts to plan and deliver student-sensitive lessons, but he was not sure how it would affect his teaching career long-term.

Jane. Jane came to the group excited about the opportunity to work with her colleagues and develop student-sensitive lessons. Early in the study, she shared that she needed time to adjust to the great student diversity within the school and within her own

classes. Her previous experience included work with students who had recently arrived from the same geographical area and had very limited English language skills. She confirmed that the strategies for teaching mathematics she learned at her previous school were not directly applicable at NSMS, although she occasionally adjusted and used them in the classroom.

Jane constantly searched for ways to apply new student-sensitive approaches to her pre-algebra classes, and took steps to improve her instruction for the benefit of her students as NCTM suggested (NCTM, 2000). When she was not sure how to apply the construct-a-concept objectives appropriately, she made arrangements and found time to go and observe Sid teaching a science lesson using the same objective. She began applying this type of lesson gradually in her pre-algebra class before the team was ready to present the lesson to her colleagues.

Jane was the only lesson study team member who used a team lesson with more than one class. She was not able to reserve the climbing gym, and she used an alternative to make the lesson student-sensitive:

> I took them out around and walk upstairs and downstairs, and walked some ramps, and I had them race up a ramp and down a ramp, and we talked about which one was harder and why. And then we talked about the side of the wall, so how is the side of the wall different than the ground, and well it was flat, so how would you describe it differently, so I tried to wing it a little bit, get in some real life applications without going to the climbing wall. So that's what I did, but it just seems really obvious, that if you can make it real life, and make them real, and not just on the paper, it's like—oh, that building has those slopes, and then you know it is going to retain, they are going to have that background knowledge and it's going to stick.

Jane was actively searching for ways to provide the experience of discovering slope to her other pre-algebra class. She shared that this modified experience changed the

learning atmosphere in this class, and that student participation was noticeably increased. This experience further motivated Jane to dedicate time and effort to the development of student-sensitive lessons. She suggested possible summer collaboration where teachers could work to develop a number of these lessons, and then teach them throughout the school year.

Jane's experience with the lesson study team and the student response she observed further motivated her to use student-sensitive lessons in her practice. She felt comfortable teaching the lessons with or without observers, but wanted to continue to develop them in collaboration:

> I think it is good to collaborate, and I've learned that…learning takes patience. I feel it is more effective when you are collaborating and working with other people. As a professional myself, it helps me when I talk to other people, how did they teach that, did it work, did it not work, I am doing it this way and I do not know exactly how to make this better…. So for me, I think I feel that I learn a lot when I am working with other people, and hearing their opinions, and their thoughts on things and so…maybe a greater understanding, a perspective, is what I learn when I interact with other people.

Jane was very enthusiastic about the lesson study and the opportunities for planning and teaching student-sensitive lessons it offered. She supported the model, and continuously sought opportunities to connect the work of the lesson study group with her pre-algebra classes. Her learning as a new teacher included intentions to use more student-sensitive lessons in her practice.

Sid. Sid's attitudes toward his ability to develop and implement student-sensitive instruction were influenced by his opinion about collaborative professional development and the level of support it received at school, district, and state levels. Every time we discussed the value of the student-sensitive lesson study, he was convinced that this was

the best way to work on meeting the needs of diverse learners. Having said that, he would immediately shift the conversation toward two issues: officially allocated time for teacher professional development built in teachers' weekly schedules, and teacher compensation. Sid believed that these two components were critical for any professional development in general, and for collaboration in particular. He was willing to continue working with others to create student-sensitive lessons, but thought that the only way to attract teachers to the professional development was to provide them with time and resources.

When I asked Sid how the student-sensitive lesson study influenced his understanding of this type of instruction, he summarized:

> The role of the vocab[ulary], and the role of the inductive model and the graphing representation—they kind of roll together, that is a great way to engage English language learner to step outside of the pure written word but to also graphically represent things so as to create an understanding of the English [language], and that is a good thing. And then also just like using examples, just being cognizant of demographics in your classroom, the Hispanic kids and not talking about hockey, and we used Ronaldino, the soccer player, just little things like that that do that tend to reach out better. Acknowledge their previous knowledge, their culture, just little things like that in a reaffirming way.

The soccer example mentioned by Sid was one example of his efforts to include student-sensitive elements in his teaching. On the day after he taught the lesson on fractions, he reviewed the concept with the class and extended it to equivalent fractions. He knew that several students in his class were soccer fans, and used a scenario with a famous soccer player they recognized. His positive attitude toward the lesson study was also driven by the positive effects on students' engagement. After the lesson on slope was taught, he commented:

> I am just benchmarking and I am kind of profiling, but I am looking at the kids that typically do not do work, and I am just picking a few of them that were on

> task. So yes, I was pretty impressed actually of how well this actually went and how many kids were engaged.

Sid was supportive of student-sensitive instruction and the lesson study model, but felt that a successful implementation depended on creating an atmosphere of appreciation and commitment for professional development. His attitude toward his own student-sensitive teaching was a mix between his high regard for collaboration as the professional development model for teachers of diverse learners, and his frustration with the lack of specific administrative decisions that would make such collaboration possible.

The lesson study group. In our interviews, the lesson study team members talked about their new awareness of the influence of instructional decisions about the mathematics learning of diverse student groups. The recognition of this connection was the first step toward a shift in their standards for teaching (NCTM, 1991). Their participation in the lesson study positively influenced their understanding of the role of language proficiency for mathematical understanding, and provided opportunities to learn how to develop mathematics lessons that account for linguistic diversity in the classroom. A big advantage of the models was the opportunity to share the ideas and practice of student-sensitive teaching with peers. This continuous exploration of existing knowledge and experience was challenging but rewarding. The teaching observations were a potential source of discomfort, but the teachers were positive about the visits to their classrooms. This mix of teacher attitudes supports findings on teachers' attitudes toward lesson study in the United States (Puchner & Taylor, 2004).

The collaborative nature of lesson study was one reason for the teachers to describe it as engaging and motivating. Having common goals was one of the driving

forces behind the teachers' commitment to the group. As Sid enthusiastically explained, "You get the handful of smart teachers, around the table, with a common goal, you know the research is clear, if you collaborate, your outcomes are going to be light years better than working in isolation." Tom supported his view and claimed, "That type of collaboration has to happen." Jane added, "I think it always helps when you are collaborating. Because you are getting ideas…. I think the results help all kids, really, and so I think it's good to work together and to collaborate."

The lesson study was an environment where teachers could share professional concerns and receive professional advice in a collegial but informal atmosphere. They saw it as an opportunity to fulfill an outstanding need for professional communication. As Gladys summarized, "Teaching in isolation is probably the worst thing for all of those children, because then maybe one person is doing something great, and the other ones would never know it, or use it, or try it. So I really like the concept [of the lesson study]; I think it has a lot of value." The teachers communicated ideas about mathematics learning and teaching, searched for student-sensitive connections, and made steps toward providing meaningful mathematical instruction to their diverse student classes. At the same time, they took some time to talk about events at the school, professional concerns, responsibilities, and ideas. They confirmed that this type of professional development suited their personal and professional needs (Glickman et al., 2007), and their active participation was one proof that they found value in it.

The teachers associated the student-sensitive lessons with the work of the lesson study team. The support from the consultant and the fellow teachers was a significant

contributor to the teachers' confidence in the appropriateness of the instructional methods they used. The lesson study experience triggered their increased understanding of the need for student-sensitive teaching. This recognition resulted in the teachers starting to look deeper into their instructional practice, and that influenced, according to their own observations, the mathematics learning of their diverse student groups.

One manifestation of the teachers' attitudes toward student-sensitive teaching was the fact that they either implemented the planned lessons immediately in their classrooms, or were planning to do so in the very near future. They made additional efforts to adjust the lessons to the specific group of students they taught, and made appropriate adjustments to accommodate for available resources. That showed that the teachers were critically reassessing the planned lessons. They were using what they have learned about student sensitive teaching to adjust and adapt their instruction further to the needs of the specific diverse groups in the classroom.

The length of the planning cycles was one feature of the professional development model that appeared to concern teachers. They had relative control over the length of a lesson study cycle because they planned on a particular week when a lesson would be taught. Although they made this decision as a group and their meetings within the allotted timeframe were filled with professional discussions, they were concerned that this type of planning did not result in a large number of planned lessons. Chokshi and Fernandez (2002) described this type of reaction to the lesson study model as specific to the United States. It was attributed to the misunderstanding that lesson study is about developing a number of exemplary lessons that could be reproduced in any classroom with success.

The teachers expanded their concern about a lack of time through the lens of student-sensitive teaching that might require longer instructional time. In addition, the long-term lesson study was a preferred model for collaboration, but it also suggested a long-term incremental improvement of student achievement and not fast improvement as preferred by administrators and districts. As experienced by the teacher's first-hand, student-sensitive teaching required additional commitment to learn appropriate strategies and how to apply them. These challenges jeopardized teachers' attitudes toward student-sensitive teaching, but they remained committed to it.

In our conversations, teachers were hesitant to elaborate on their personal readiness to plan and deliver student-sensitive lessons. Two possible reasons for this outcome surfaced throughout the exploration. First, the three lesson study cycles did not provide extended experiences in planning and teaching student-sensitive lessons. A sustained implementation could lead to more significant and noticeable outcomes. This is a common challenge for professional development in the U. S. (Gordon, 2004). Second, the lesson study was completed close to the end of the school year, and the need for immediate planning and implementations of student-sensitive lessons was not going to be pressing until the start of the next school year, if the lesson study group would renew its work.

The professional development opportunities that met the actual needs of the teachers at NSMS appeared quite limited, and the lesson study became a venue for them to express their legitimate concerns. Still, the teachers remained with the lesson study team until the end of the third student-sensitive lesson study cycle, and this was one sign

of their interest in student-sensitive lesson study and teaching.

The teachers began making steps toward better meeting the needs of their diverse mathematics learners. By working with the lesson study group throughout most of the school year, they demonstrated their willingness to start changing their instructional approaches. They were working toward student-sensitive instruction, but needed more time and experience to become committed to it. Although they were sometimes in doubt, they managed to maintain positive attitudes toward their abilities to plan and deliver student sensitive mathematics lessons. They appeared willing to put in their share of effort when presented with the opportunity. This affirmed that the teachers were taking steps to support the learning of their diverse groups of students as NCTM suggested (NCTM, 2000). However, they put a strong emphasis on some factors that influenced their learning and attitudes toward the student-sensitive lesson study professional development.

Factors Influencing Teachers' Learning and Attitudes

The last question of this investigation was: What factors influenced teacher's learning and attitudes about student sensitive lesson planning and delivery? The teachers talked about three key factors: the role of time, the professional development climate in the school, and the responsibilities imposed on them by testing requirements and schedules. A discussion of these factors follows.

Time. Time affected the lesson study team as a whole, and the teachers as individual participants. It became an issue even before the lesson study group met

initially. It continuously challenged the progress of the group, its timeline, and was the reason for my participation as schedule and attendance coordinator.

The theme of time appeared on three different levels, all of which were relevant to the teachers' professional learning. First, time was relevant to their schedules, their availability for meetings, and their opportunities to continue learning and planning outside those meetings. Second, time appeared to be the most significant challenge teachers faced when working to cover the content curriculum, to get the students prepared for end-of-level testing, and to implement student-sensitive lessons. Third, time was related to school-wide opportunities for professional growth and learning.

Time and teachers' schedules. During our conversations, Sid drew a picture that highlighted the many controversies among quality teaching, effective professional preparation, teacher learning, and available time:

> Say you are a loan officer. If a loan officer met with clients from eight in the morning until 5 at night, you are talking to clients, granted, you have 20-minute lunch like we have, but they are talking to their clients for this entire 8- to 10-hour day. Then the loan officers, on their own time, need to do all the paperwork. And I posed that to a loan officer, and she thought it was the most ludicrous thing that might happen: "Are you kidding me? I'd be up until 2 in the morning!" And I said exactly! We are asked to stand in front of our classroom, for eight hours. At North State we get a 40-minute prep, which is not too much, we get a little bit done, but not too much. And then at the end of the day, we are asked to score critical thinking and writing samples, and develop research-based, standard-based units.

Sid's description was a summary of a regular teacher's workday at NSMS, but time issues did not end with grading and planning. As mentioned earlier, every one of the participants was involved in a number of extra-curricular activities: basketball for Jane, numerous student clubs for Gladys and Tom, and a number of committees for Sid. These commitments required extra hours in addition to the daily teaching responsibilities. Time

was a reason for the teachers to focus on planning daily instructional activities rather than commit to participation in a professional development that might or might not add significant value to their learning and practice. It was a hard choice to commit to dedicate the time to a long-term professional development when there was daily grading and planning to be done.

During the study, teachers' willingness to learn and grow professionally was affected by the lack of time for activities outside their school obligations. Although Tom, Jane, Sid, and Gladys made a real effort to come to every meeting and were truly committed to the discussions, they often had to cut their meeting attendance short. The rest of the group always continued to carry on the discussion and moved on with the lesson, but the absence of one great contributor might have changed the dynamics of the meeting and affected the final content of the lessons taken to the classroom. Scheduling a group meeting was also a challenge, especially at times when there were additional activities going on at the school. The participants suggested that lack of time was a chronic issue for them and their profession, and it was a result of the structure of the educational process and the role teachers are expected to play in it.

Time and curriculum. The second time strand that affected the opportunities for teacher learning was the curriculum timeline and the large number of content units that needed to be covered in a trimester and throughout the school year. One of the most important expected outcomes tied with the scope of the mathematical content curricula were the end-of-level tests, and coverage of all material required the alignment of the lesson study with the curriculum sequence. Student-sensitive lessons possibly required

extra instructional time, which in turn jeopardized the opportunities to teach other required core content. According to the teachers, through their lesson study experiences they confirmed that time and the required curricular coverage appeared to be in conflict when working to provide student-sensitive mathematics lessons. As Sid, Tom, and Jane experienced firsthand, the delivery of such lessons required more time than the current curriculum scope allowed, and finding this time was a serious challenge.

Time and professional learning. Although the teachers acknowledged that some professional development time was built into their yearly schedule, they were unanimous that this time was not enough. For the 2007-2008 school year, the North State's school district had two full and two half professional development days before the school year started, then two more half professional development days throughout the school year—one each after the end of the first and second trimesters. The lesson study group members acknowledged multiple times that the lesson study format, with its consistency and regular meetings spread in smaller units of time, was conducive to their learning. However, not having time allotted by the school schedule was preventing them from being proactive about their own learning. The daily teaching load and the other responsibilities relevant to teaching had an effect on the time teachers dedicated to their professional learning. By voicing their opinion about time as one of the most critical challenges to their professional learning, the study participants created a strong connection between the available opportunity to learn in professional collaboration and their overloaded days.

Professional Development Climate and Opportunities

Parallel to their experiences with student-sensitive lesson planning and teaching, the study participants positioned the lesson study work within the ongoing struggle to establish sustained, teacher-centered professional development as inseparable from teachers' everyday practice. All teachers talked about the significance of the present opportunities for professional development at the school. They reasoned that they needed support to extend from the top down because their participation in the lesson study professional development and therefore, their continuous efforts to plan student-sensitive lessons, depended on the climate at the school and the time they had allotted. The lesson study group was one sign the teachers were prepared to take charge and initiate the work. Still, there was a need for reasonable and sufficient professional development arrangements to accommodate the process of planning and delivering student-sensitive mathematics lessons. Without these arrangements, any positive attitude toward this type of teaching appeared unfounded. The teachers expanded their reflections on possible factors that influenced their learning from the lesson study by noticing and reflecting only on the immediate events within the group. They were cognizant of the influence of external factors on the work of the group. This helped them construct accounts that validated their observations and established strong connections between their experiences outside the lesson study group and their learning as lesson study group members.

The lesson study group members could not separate their personal attitudes toward the role of the lesson study from their attitudes toward ongoing processes in the school. Their abilities to plan and teach student-sensitive lessons were closely tied to the

opportunities for professional growth within the school. These views reflected the current trends in professional development initiatives, the emphasis on administrative support, and their focus on teacher engagement and active participation (Gordon, 2004; Loucks-Horsley & Matsumoto, 1999; Loucks-Horsley et al., 2003).

Influence of Testing and Accountability

The issues of testing, accountability, and curriculum came in contrast with the lesson study teaching experiences. They brought to the surface the contradictions among the need for student-sensitive mathematics instruction, its positive influence on teachers' learning, and the weight of the end-of-level tests on teachers, students, and schools. The lesson study experience was thus consistent with findings reported in the literature (Ladson-Billings, 1997; Schoenfeld, 2002). One possible reason for this contradiction was that a transition to continuous student-sensitive teaching requires adaptation from both teachers and students in the classroom, but there was no time for transition because of the material that needed to be covered in order to meet the requirements of the test. One possible solution to this dilemma would be to build some time into the year-long teaching schedule in the initial planning stages. Teachers could start planning lessons before the school year begins. This approach would be in unison with the summer lesson study experience suggested by the team members.

The lack of correspondence between teaching and learning in a student-sensitive way and mandatory testing was quite discouraging for the teachers. They came back to this issue repeatedly. The professional standing of the teachers depended, to a very high degree, on the end-of-level test scores of their students, and they shared that they could

get satisfactory results with at least some of their students using traditional instructional methods. This choice was a struggle for them, because they saw firsthand that the student-sensitive instruction does matter and could make a difference. They also realized that if they did teach consistently in a student-sensitive way, their students would have the critical skills needed to solve the test items. In this scenario, though, they were again facing the challenges posed by the previously discussed group of factors—the need for professional development opportunities.

The teachers wanted to continue expanding their opportunities to learn more about student-sensitive mathematics instruction, but were significantly limited by external factors. Although all the teachers claimed they would go back to collaborative planning of lessons if provided some extra time, it appeared their final decision would still be strongly influenced by the assessment and evaluation structures that would be in place. The teachers still asserted that the lesson study allowed them to become more responsive to the needs of their diverse student groups. Through their professionalism and persistence working in the lesson study, the teachers demonstrated that this form of professional development had a value for them and their work at North State Middle School.

Implications

Available research on lesson study in the U.S. shows that lesson study participation has different benefits for teachers (Fernandez, 2005; Hurd & Licciardo-Musso, 2006; Lewis et al., 2006; Taylor et al., 2005). The focus of this study was the

effect of teachers' participation in student-sensitive lesson study on teachers' learning. One distinguishing characteristic of this model was the participation of a diversity consultant. The findings of the study have implications for mathematics professional development planning implementation. They are presented next.

Lesson Study Has Potential as Student-Sensitive Collaboration

The student-sensitive lesson study emerged as one teacher-led alternative to the envisioned culturally responsive professional development. The results from this study suggest that student-sensitive lesson study provides teachers with the environment and the collegial support they need to begin working on instruction that considers the principle of equity in the classroom. The student-sensitive components for this lesson study were not predetermined, but emerged throughout the professional conversations of the teachers. They were also influenced by the training and experience of the diversity consultant and her ability to notice the instructional decisions that possibly affected the mathematics learning of the diverse student groups.

The lesson study team could invite consultants with a specific area of expertise of one element of student-sensitive learning to provide more in-depth learning about aspects of student-sensitive instruction. For example, one or more lessons could be developed focusing on ESL instructional strategies and possible ways to incorporate them appropriately in mathematics lessons, and an ESL consultant could support the teachers in these efforts. These experiences could then be extended to learning about the role of context in instruction, and a consultant—possibly a person with experience learning

mathematics in different educational traditions—could be invited to provide examples and directions for the teachers. These consultants could also observe the lesson teaching and provide feedback to the team. This approach is more challenging due to finding consultants with appropriate expertise but is an option for making the student-sensitive instruction more explicit for the teachers.

The Lesson Study Model Should Be Followed

The original lesson study model includes debriefing, reflection, and revision as one of the steps of the lesson study cycle. In this study, the teachers met for a group debriefing only after the first lesson, and this restricted the opportunities for critical reflections on the other lesson implementations.

A student-sensitive lesson study should closely follow the steps of the lesson study model. The teachers and their student-sensitive instruction might benefit from an in-depth analysis of the lesson and its effects on students' participation, engagement, and learning. This in turn might increase teachers' sensitivity to the needs of their students and the role of their instruction in meeting these needs. A complete lesson study cycle would support the development and the implementations of more student-sensitive mathematics instruction.

In-School Support for Student-Sensitive Lesson Study Critical

In-service professional development is usually initiated by the school districts and the school administrations. Lesson study is a teacher-initiated collaboration that addresses

current concerns relevant to students' learning. Even if the student-sensitive lesson study receives district approval and is financially supported by an outside agency, it is critical that it receives strong support within the school.

The strengths of lesson study should be made known to the school administration before work begins, and then regularly throughout the process. Although there is little empirical data to support claims for increased student achievement as a result of teacher participation in lesson study, the model is strongly aligned with the current dominant frameworks of effective professional development and is being endorsed by teachers and researchers. It is a long-term collaboration that should lead to gradual improvement, and administrators should be aware of its focus on teachers' practice. The student-sensitive mathematics lesson study adds to the lesson study benefits, because it allows teachers to work together on their mathematical content knowledge and teaching, and on addressing two of the greatest challenges to the U.S. educational system—the growing diverse population and the need for equity in mathematics learning. It appears there are emerging aspects that may help create a model for future research in this area. Administrative support could be demonstrated by providing the time for teachers to attend meetings and helping to arranging for substitute teachers to cover for team members when they observe a lesson. An administration-endorsed student-sensitive lesson study would provide the solid ground to focus immediately on the pressing issues in the classroom rather than forcing teachers to deal with organizational problems.

The lesson study members need to be proactive in approaching administrators and placing their requests. One way to receive long-term support would be to invite

administrators to group meetings and lesson demonstrations. A working, professional communication between a student-sensitive lesson study team and administration would ensure a school environment that is beneficial for productive work.

Student Sensitive Mathematics Teaching Should be Made Known

The student-sensitive lesson study provides one professional development option for mathematics teachers who have acknowledged the need for change in their teaching to meet the needs of their diverse student groups. The lesson study groups should be open to every mathematics teacher, and the lesson study group should invite them and other interested professionals to visit and observe. The lesson study team could hold an "open house" to share the student-sensitive lessons they have created. Thus, both team members and non-participating faculty would benefit from sharing the lesson study work with wider audiences and learning new approaches to teaching mathematical content and teaching in a student-sensitive way. Such arrangements may also initiate a broader awareness throughout faculty of how teacher-designed instruction could become more student-sensitive.

Teachers' Learning Is Influenced by Lesson Study Group Characteristics

The student-sensitive lesson study model offers opportunities for teachers to revise and reflect on their mathematical knowledge and teaching while developing meaningful and engaging lessons. This type of work involves continuous revisiting of one's personal conceptual understanding of mathematical content and re-evaluating ways

of teaching it. It also includes learning about their possible student-sensitive connections. The process occurs in a group environment where all participants share their experiences and fine-tune their knowledge and teaching when sharing with and hearing from others. The process and the discussions are aligned with the requirements of the mathematics core curriculum. This complexity suggests some organizational steps that could have a positive influence on creating the lesson study environment conducive to teachers' learning. The size of the lesson study group should be small, four or five people. Meetings should be held regularly, possibly weekly, and their schedule should be aligned with the school calendar, school breaks, extra-curricular activities, and testing schedules. Given the busy schedules of the teachers, meeting planning should be assigned to one person who would maintain close connections with all group members. While every student-sensitive mathematics lesson study team will function in a unique, member-appropriate way, the suggestions outlined above would support smoother functioning that enhances the opportunities for teacher learning.

The Diversity Consultant Supports Teachers' Learning

The role of the consultant is central to the student-sensitive mathematics lesson study. The qualifications of the diversity consultant will be unique for every situation and school where lesson study takes place. These skills and qualifications will also affect the student-sensitive components of the lessons and relevant teachers' learning. The participation and contributions of the consultant need to be balanced with those of the other team members. Negotiation of this balance within the lesson study group can affect

the learning opportunities for the teachers.

The student-sensitive lesson study team works on instruction with their students in mind. A diversity consultant who is a faculty member and knows the students and their possible challenges in mathematics can provide student-sensitive insights relevant to them. In addition, intragroup relationships are important for the progress of the group work. It might beneficial for teachers to hold a meeting where team members can introduce each other in significant detail, voice their goals, and describe their expectations of possible collaborative efforts.

The Teachers Actively Assess the Student-Sensitive Lesson Study Model

Lesson planning and observations are at the center of the student-sensitive lesson study work. The lesson study model offers the framework for structuring the work of the group, and the teacher participants gain insights about the effects of its student-sensitive components. Based on their experiences, the team can propose modifications that enhance the student-sensitive components. For example, the lesson study model suggests that every lesson be taught once, then revised, then possibly re-taught to another group of students. The teachers in this study suggested that all mathematics team members teach the originally planned lessons to their classes. Thus, they could collect richer observational data and receive input on the student-sensitive nature of the lesson from three different student groups. They would then work and revise the lesson if needed, and possibly reteach it to one of the classes as a revision. These multiple implementations of one lesson would allow for stronger emphasis on the student-sensitive components of the

mathematics lessons. The team members would practice and observe multiple times the same student-sensitive instruction, and this would enrich their opportunities to learn.

Limitations

Time

Time was a limitation for this study in more than one way. This influence was manifested from the very beginning, when I approached teachers with an invitation to participate in the study. All who declined reasoned that they could not spare any time for additional professional activity. The teachers that agreed to participate declared that they were interested in developing instruction sensitive to their diverse groups and that defined the sample of the study as "purposeful." These teachers were, however, the ones able to incorporate the additional load into their schedules, and this suggested that the participants in this study could also be considered a convenience sample.

Time was also a limitation with respect to teacher participants being able to manage the work of the lesson study group. Early in the study, I accepted responsibility for the scheduling of the lesson study meetings. The teachers and I acknowledged that the lack of allotted professional development time in their schedules would make planning complicated and time consuming, and no team member was ready to accept this additional load. My drive as a researcher and discipline as an individual possibly affected the consistency of the meetings as far as teachers' schedules allowed and the completion of three study cycles. The teachers shared that my continuous communication with them was a connecting element they needed to keep working together. Without it, the lesson

study group might have ceased to exist. My role as a scheduling manager, however, increased the opportunities for communication with the participants outside of the formal meetings, helped me to create better rapport with them, provided me with closer look in the time-related challenges the teachers were facing, and allowed me to observe the group in multiple situations.

Time was the most influential factor for the occurred revision of the lesson study framework. The group work began with a complete four-step cycle, and it was expected that over the five-month period the team worked together, the team would further master and improve the application of the model. Instead, the lesson study cycle was gradually shortened and finally excluded the cycle of debriefing and analysis. The teachers were not able to get together due to multiple school responsibilities. The lesson study was voluntary and therefore the one activity that was possible to skip.

Time-related issues also influenced the data analysis. For example, I approached the team members with a request for member checking close to the end of the school year, when the data analysis was complete. At the time, the teachers' availability to meet was minimal, and the time they were able to spend on reading the analysis was scarce. I asked them to read a limited number of pages, where only their individual input was analyzed. The feedback that I received from the teachers could have been different if they had time to read more of the interpretation.

The length of the study was another limitation. Due to the upcoming end-of-level testing, the lesson study group needed to complete the third cycle before the end of April. More lesson study cycles would include discussions of broader content and therefore,

more opportunities for implementation of student-sensitive components. A year-long study could provide greater insights about the student-sensitive lesson study model and its effects on mathematics teachers and their instruction.

The lesson study team member availability for meetings was also a limitation of the study. When teachers were absent or attended the meeting for only a portion of the time, the degree of collaboration in the group was negatively affected. The possible contributions of the absentee could have altered the direction of the lesson study work, or could have added components to enrich the student-sensitive nature of the lesson study work.

Diversity Consultant

The characteristics of the diversity consultant for the lesson study group were a limitation for this study. Gladys' understanding of instructional components and decisions that might be affecting students' learning of mathematics influenced the student-sensitive components of the mathematics lessons and determined the learning opportunities for the teachers. She also was not a representative of the Hispanic/Latino ethnic group. Her contributions were grounded in her own pedagogical practice and her understanding of diversity in education. A diversity consultant with different beliefs and expertise could have influenced the mathematics teachers' learning about instruction for diverse student groups in a different way.

Recommendations for Future Research

The student-sensitive lesson study was a first attempt to include a student-

sensitive teaching and learning component in a professional development model that is gaining significant popularity among teachers in the U.S. The teachers involved in this exploration reported multiple learning opportunities unique to the model. Further examination of this model could provide data in two possible directions: effective professional development models and mathematics learning and achievement of diverse student groups.

One important characteristic of any effective professional development model is sustainability. The student-sensitive lesson study took place over a period of five months. Although this time period was sufficient to obtain rich data on this initial implementation, future research-oriented implementation that is at least one full school-year long would allow for multiple lesson implementations and greater insights about the student-sensitive component of the model. Future, longer studies could compare the effects of the model in two or more different schools. The data would provide insights on the effects of diversity on the student-sensitive lesson study model.

The role of the diversity consultant is key to this model. If the study could be extended over two or more school years, people with varying expertise could be invited to fill the role of a consultant every year. Thus, more information would be collected on the influence of the diversity consultant on the learning of the teachers and on the outcomes of the model implementations.

Longer study implementations could also focus the research efforts on the most important outcome of any professional development: student learning and achievement. A baseline of student achievement could be established at the beginning of the model

implementation, and then multiple measurements of student achievement could be taken after every lesson. This data could be quantitatively analyzed to observe if the application of student-sensitive lesson study would result in change in mathematics student achievement. In addition, the possible change to student-sensitive instructional practice should be described using observations, and student and teacher interviews. Such comprehensive research efforts could provide needed empirical data for the effects of student-sensitive mathematics instruction in the classroom. It would also examine in-depth the role of the student-sensitive lesson study in connecting teacher practice and student achievement.

REFERENCES

Adamson, L. B., & Chance, S. (1998). Coordinating attention to people, objects, and symbols. In A. M. Wetherby, S. F. Warren, & J. Reichle (Eds.), *Transitions in prelinguistic communication: Preintentional to intentional and presymbolic to symbolic* (pp. 15-37). Baltimore: Brookes.

Akiba, M., LeTendre, G. K., & Scribner, J. P. (2007). Teacher quality, opportunity gap, and national achievement in 46 countries. *Educational Researcher, 36*(7), 369-387.

Ascher, M. (1991). *Ethomathematics: A multicultural view of mathematical ideas.* Pacific Grove, CA: Brooks/Cole.

Axel, E. (1997). One development line in European activity theory. In M. Cole, Y. Engeström, & O. Vasquez (Eds.), *Mind, culture, and activity seminal papers from the laboratory of comparative human cognition* (pp. 128-146). Cambridge, UK: Cambridge University Press.

Banks, J. A. (2001). *Cultural diversity and education: Foundations, curriculum, and teaching.* Boston: Allyn and Bacon.

Bogdan, R. C., & Biklen, S. K. (1982). *Qualitative research in education: An introduction to theory and methods.* Boston: Allyn and Bacon.

Bol, L., & Berry, R. O. (2005). Secondary mathematics teachers' perception of the achievement gap. *The High School Journal, 88*(4), 33-43.

Brand, B. R., Glasson, G. E., & Green, A. M. (2006). Sociocultural factors influencing students' learning in science and mathematics: An analysis of the perspectives of African American students. *School Science and Mathematics, 106*(5), 228-236.

Brenner, M. E. (1998). Adding cognition to the formula for culturally relevant instruction. *Anthropology and Education Quarterly, 29*(2), 214-244.

Cangelosi, J. (1996). *Teaching mathematics in secondary and middle school: An interactive approach.* Upper Saddle River, NJ: Prentice Hall.

Carpenter, T., & Lehrer, R. (1999). Teaching and learning mathematics with understanding. In E. Fennema & T. A. Romberg (Eds.). *Mathematics classrooms that promote understanding* (pp. 19-32). Mahwah, NJ: Erlbaum.

Carroll, J. (2005). Developing effective teachers of mathematics: factors contributing to development in mathematics education for primary school teachers. In P. Clarkson, A. Downton, D. Gronn, M. Horne, A. McDonough, R. Pierce, et al. (Eds.), *Building connections: Theory, research and practice, Proceedings of the 28th Annual Conference of the Mathematics Education Research Group of Australasia* (pp. 201-216). Sydney, Australia: MERGA.

Chokshi, S., & Fernandez, C. (2004). Challenges to importing Japanese lesson study: concerns, misconceptions, and nuances. *Phi Delta Kappan, 85*(7), 520-525.

Chokshi, S., & Fernandez, C. (2005). Reaping the systematic benefits of lesson study: Insights from the U. S. *Phi Delta Kappan 86*(9), 674-680.

Chubbuck, S. M. (2004). Whiteness enacted, whiteness disrupted: The complexity of personal congruence. *American Educational Research Journal, 41*(2), 301-333.

Cole, M. (1996). *Cultural psychology: A once and future discipline.* Cambridge, MA: The Belknap Press of Harvard University Press.

Cole, M., & Cole, S. R. (2001). *The development of children*. New York: Worth.

Cox. P. F. (producer). (1989). *Honey, I shrunk the kids.* [Motion Picture]. United States: Buena Vista Pictures.

Creswell, J. W. (1998). *Qualitative inquiry and research design: Choosing among five traditions.* Thousand Oaks, CA: Sage.

Creswell, J. W. (2003). *Research design: Qualitative, quantitative, and mixed methods approaches* (2nd ed.). Thousand Oaks, CA: Sage.

Daniels, H. (2001). *Vygotsky and pedagogy*. New York: Routledge Falmer.

Darling-Hammond, L., & McLaughlin, M. W. (1999). Investing in teaching as a learning profession: Policy problems and prospects. In L. Darling-Hammond & G. Sykes (Eds.), *Teaching as the learning profession: Handbook of policy and practice* (pp. 376-414). San Francisco: Jossey-Bass.

Davis, B. (2004). *Inventions of teaching. A genealogy.* Mahwah, NJ: Erlbaum.

Desimone, L., Smith, T. M., & Phillips, K. J. R. (2007). Does policy influence mathematics and science teachers' participation in professional development? *Teacher College Record, 109*(5), 1086-1112.

Diamond, B. J., & Moore, M. A. (1995). *Multicultural literacy: Mirroring the reality of the classroom.* New York: Longman.

Dilg, M. (2003). *Thriving in the multicultural classroom: Principles and practices for effective teaching.* New York: Teachers College Press.

Echevarria, J., Vogt, M., & Short, D. (2004). *Making content comprehensible for English learners: The SIOP model* (2nd ed.). Boston: Pearson.

Elmore, R. F. (1996). Getting to scale with good educational practice. *Harvard Educational Review, 66*(1), 1-26.

Farmer, J., Hauk, S., & Neumann, A. M. (2005). Negotiating reform: Implementing process standards in culturally responsive professional development. *The High School Journal, April/May*, 59-71.

Ferguson, R. F. (2006). 5 challenges to effective teacher professional development. *Journal of Staff Development, 27*(4), 48-52.

Fernandez, C. (2002). Learning from Japanese approaches to professional development: the case of lesson study. *Journal of Teacher Education, 53*(5), 393-405.

Fernandez, C. (2005). Lesson study: A means for elementary teachers to develop the knowledge of mathematics needed for reform-minded teaching? *Mathematical Thinking and Learning, 7*(4), 265-289.

Fernandez, C., & Yoshida, M. (2004). *Lesson study: A Japanese approach to improving mathematics teaching and learning*. Mahwah, NJ: Erlbaum.

Fernandez, C., Cannon, J., & Chokshi, S. (2003). A US-Japan lesson study collaboration reveals critical lenses for examining practice. *Teaching and Teacher Education, 19*, 171-185.

Flores, A. (2007). Examining disparities in mathematics education: Achievement gap or opportunity gap? *The High School Journal, 91*(1), 29-42.

Flores, A. (2008). The opportunity gap. *The Inaugural TODOS, Volume 1*: National Educators Association.

Fushino, K. (2004). *Sociocultural theory and situated cognition theory: An interim understanding of how they can inform cooperative learning.* Retrieved April 15, 2006, from www.iasce.net/Conference2004/23June/Kumiko/Kumiko%20IASCE%20conference%20presentaion%20draft%20revised.doc

Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., & Yoon, K. S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal, 38*(4), 915-945.

Gauvain, M. (2005). Sociocultural context of learning. In A. E. Maynard & M.E. Martini (Eds.), *Learning in cultural context: Family, peers, and school.* New York: Kluwer Academic/Plenum.

Gay, G. (2000). *Culturally responsive teaching: theory, research, and practice.* New York: Teachers College Press.

Gentemann, K. M., & Whitehead, T. L. (1983). The cultural broker concept in bicultural education. *Journal of Negro Education, 52*(2), 118-129.

Glesne, C. (2006). *Becoming qualitative researchers: An introduction* (3rd ed.). Boston: Pearson.

Glickman, C. D., Gordon, S. P., & Ross-Gordon, J.M. (2007). *SuperVision and instructional leadership: A developmental approach* (7th ed.). Boston: Pearson.

Gordon, S. P. (2004). *Professional development for school improvement: Empowering learning communities.* Boston: Pearson.

Guskey, T. R. (2003). What makes professional development effective? *Phi Delta Kappan, 84*(10), 748-750.

Hall, G. C., & Barongan, C. (2002). *Multicultural psychology*. Upper Saddle River, NJ: Prentice Hall.

Hancock, D. R., & Algozzine, B. (2006). *Doing case study research: A practical guide for beginning researchers.* New York: Teachers College Press.

Hansman, C. A. (2001). Context-based adult learning. In S. B. Merriam (Ed.), *The new update on adult learning theory* (pp. 42-52). San Francisco: Jossey-Bass.

Harris D. N., & Herrington, C. D. (2006). Accountability, standards, and the growing achievement gap: Lessons from the past half-century. *American Journal of Education, 112*(2), 209-238.

Haviland, V. S. (2008). "Things get glossed over:" Rearticulating the silencing power of Whiteness in education. *Journal of Teacher Education, 59*(1), 40-54.

Hodge, L. L. (2006). An orientation on the mathematics classroom that emphasizes power and identity: Reflecting on equity research. *The Urban Review, 38*(5), 373-385. Retrieved June 1, 2008, from www.springerlink.com/index/00G1555P85W6U511.pdf

Hollins, E. R. (1996). *Culture in school learning: Revealing the deep meaning.* Mahwah, NJ: Erlbaum.

Howard, G. R. (1999). *We can't teach what we don't know: White teachers, multiracial schools.* New York: Teachers College Press.

Howe, K. R., & Berv, J. (2000). Constructing constructivism, epistemological and pedagogical. In D. C. Phillips (Ed.), *Constructivism in education: Opinions and second opinions on controversial issues* (pp. 19-40). Chicago: University of Chicago Press.

Hurd, J., & Licciardo-Musso, L. (2005). Lesson study: Teacher-led professional development in literacy instruction. *Language Arts, 82*(5), 388-395.

Isoda, M., Stephens, M., Ohara, Y., & Miyakawa, T. (2007). *Japanese lesson study in mathematics: Its impact, diversity, and potential for educational improvement.* Hackensack, NJ: World Scientific.

Jamal, I., & Pitts, V. R. (2005). High expectations: a "how" of achieving equitable mathematics classrooms. *The Negro Educational Review, 56*(2/3), 127-34.

Jarvis, P. (1987). *Adult learning in social context.* London: Croom Helm.

Jarvis, P. (2004). *Adult education and lifelong learning: Theory and practice* (3rd ed.). London: Routledge Falmer.

Joseph, G. G. (1997). Foundations of ethnocentrism in mathematics. In A. B. Powell & M. Frankenstein (Eds.), *Ethnomathematics: Challenging ethnocentrism in mathematics education* (pp. 61-82). Albany, NY: SUNY.

Kennedy, L. M., Tipps, S., & Johnson, A. (2007). *Guiding children's learning of mathematics*. Belmont, CA: Wadsworth/Thomson Learning.

Kitchen, R. S. (2005). Making equity and multiculturalism explicit to transform mathematics education. In A. J. Rodriquez & R. S. Kitchen (Eds.). *Preparing Mathematics and Science Teachers for Diverse Classrooms: Promising Strategies for Transformative Pedagogy* (pp. 33-60). Mahwah, NJ: Erlbaum.

Kozulin, A. (2003). Psychological tools and mediated learning. In A. Kozulin, B. Gindis, V. S. Ageyev, & S. M. Miller (Eds.), *Vygotsky's educational theory in cultural context* (pp. 15-18). New York: Cambridge University Press.

Kozulin, A., Gindis, B., Ageyev, V. S., & Miller, S. M. (2003). Introduction: sociocultural theory and education: Students, teachers, and knowledge. In A. Kozulin, B. Gindis, V. S. Ageyev, & S. M. Miller (Eds.), *Vygotsky's educational theory in cultural context.* (pp. 1-14). New York: Cambridge University Press.

Ladson-Billings, G. (1994). *The dreamkeepers: Successful teachers of African American children.* San Francisco: Jossey Bass.

Ladson-Billings, G. (1995a). Toward a theory of culturally relevant pedagogy. *American Educational Research Journal, 32*(3), 465-490.

Ladson-Billings, G. (1995b). But that's just good teaching! The case for culturally relevant pedagogy. *Theory Into Practice, 34*(3), 159-165.

Ladson-Billings, G. (1997). It doesn't add up: African American students mathematics achievement. *Journal for Research in Mathematics Education, 28,* 697-708.

Ladson-Billings, G. (2006). From the achievement gap to the education debt: understanding achievement in U. S. schools. *Educational Researcher, 35*(7), 318-334.

Lancy, D. (1993). *Qualitative research in education: An introduction to the major traditions.* New York: Longman.

Lantolf, J. P. (2000). Introducing sociocultural theory. In J. P. Lantolf (Ed.), *Sociocultural theory and second language learning* (pp. 1-26). Retrieved April 10, 2006, from www.oup.com/pdf/elt/catalogue/0-19-442160-0-a.pdf

Lave, J. (1988). *Cognition in practice: Mind, mathematics, and culture in everyday life.* Cambridge, UK: Cambridge University Press.

Lave, J. (1997). The culture of acquisition and the practice of understanding. In D. Kirshner & J. A. Whotston (Eds.), *Situated cognition: Social, semiotic, and psychological perspectives* (pp. 17-36). Mahwah, NJ: Erlbaum.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation.* New York: Cambridge University Press.

Leedy, P. D., & Ormrod, J. E. (2004). *Practical research: planning and design* (8th ed.) Upper Saddle River, NJ: Prentice Hall.

Leonard, J. (2008). *Culturally specific pedagogy in the mathematics classroom: strategies for teachers and students.* New York: Routledge.

Leonardo, Z. (2002). The souls of White folks: Critical pedagogy, Whiteness studies, and globalization discourse. *Race Ethnicity and Education, 5*(1), 29-50.

Lewis, C. (2002). *Lesson study: A handbook of teacher-led instructional change*. Reston, VA: NCTM.

Lewis, C., Perry, R., Hurd, J., & O'Connell, P. (2006). Lesson study comes of age in North America. *Phi Delta Kappan, December*, 273-281.

Lipka, J., & Adams, B. (2004). *Culturally based math education as a way to improve Alaska Native students' math performance*. ACCLAIM research initiative working paper No. 20.

Lipka, J., Hogan, M. P., Webster, J. P., Yanez, E., Adams, B., Clark, S., et al. (2005a). Math in a cultural context: two case studies of a successful culturally based math project. *Anthropology and Education Quarterly, 36*(4), 367-385.

Lipka, J., Sharp, N., & Brenner, B. (2005b). The relevance of culturally based curriculum and instruction: The case of Nancy Sharp. *Journal of American Indian Education, 44*(3), 31-54.

Loucks-Horsley, S., Love, N., Stiles, K. E., Mundry, S., & Hewson, P. (2003). *Designing professional development for teachers of science and mathematics* (2nd ed.). Thousand Oaks, CA: Corwin.

Loucks-Horsley, S., & Matsumoto, S. (1999). Research on professional development for teachers of mathematics and science: the state of the scene. *School Science and Mathematics, 99*(5), 258-271

Loucks-Horsley, S., Stiles, K., & Hewson, P. (1996). *Principles of effective professional development for mathematics and science education: A synthesis of standards.* Madison: University of Wisconsin at Madison, National Institute for Science Education.

Luria, A. R. (1979). *The making of mind. A personal account of soviet psychology.* Cambridge, MA: Harvard University Press.

Malloy, C. E., & Malloy, W. W. (1998) Issues of culture in mathematics teaching and learning. *The Urban Review, 30*(3), 245-257.

Marx, S. (2006). *Revealing the invisible: Confronting passive racism in teacher education.* New York: Routledge.

Marzano, R. J., Pickering, D. L., & Pollock, J. E. (2001). *Classroom instruction that works*. Alexandria, VA: ASCD.

Mason, J. (2002). *Researching your own practice: The discipline of noticing.* New York: Routledge/Falmer.

Maynard, A. E., & Martini, M. I. (2005). *Learning in cultural context: Family, peers, and school.* New York: Kluwer Academic/Plenum.

McIntyre, A. (1997). Constructing and image of a White teacher. *Teachers College Record, 98*(4), 653-681.

Merriam. S. B. (1988). *Case study research in education: A qualitative approach*. San Francisco: Jossey-Bass.

Merriam, S. B. (2001a). *Qualitative research and case study applications in education.* San Francisco: Jossey-Bass.

Merriam, S. B. (2001b). Andragogy and self-directed learning: pillars of adult learning theory. In S. B. Merriam (Ed.), *The new update on adult learning theory* (pp. 3-14). San Francisco: Jossey-Bass.

Merriam, S. B. (2002). (Ed). *Qualitative research in practice: Examples for discussion and analysis.* San Francisco: Jossey-Bass.

Merriam, S. B., & Cafarella, R. S. (1991). *Learning in adulthood: A comprehensive guide.* San Francisco: Jossey-Bass.

Mills College. (2007). *Lesson study group at Mills College workshop handouts*. Retrieved on January 15, 2007, from http://lessonresearch.net/res.html

Nasir, N. S., Hand, V., & Taylor, E. V. (2008). Culture and mathematics in schools: boundaries between "cultural" and "domain" knowledge in the mathematics classroom and beyond. *Review of Research in Education, 32*(1), 187-240.

National Council of Supervisors of Mathematics (NCSM). (2008). *The PRIME leadership framework*. Bloomington, IN: Solution Tree.

National Council of Teachers of Mathematics (NCTM). (1991). *Professional standards for teaching mathematics.* Reston, VA: Author.

National Council of Teachers of Mathematics (NCTM). (2000). *Principles and standards for school mathematics.* Reston, VA: Author.

National Council of Teachers of Mathematics (NCTM). (2004). *The NCTM achievement gap task force: Final report*. Retrieved June 4, 2006, from www.nctm.org/about/taskforce/achievement_gap.pdf

Newman, D., Griffin, P., & Cole, M. (1989*). The construction zone: Working for cognitive change in school.* New York: Cambridge University Press.

No Child Left Behind (NCLB). (2001). *No child left behind (Public Law 107-110).* Retrieved May 15, 2005, from http://www.whitehouse.gov/news/reports/no-child-left-behind.html

Patton, M. Q. (1990). *Qualitative evaluation and research methods*. Newbury Park, CA: Sage.

Phillips, D. C. (2000). An opinionated account of the constructivist landscape. In D. C. Phillips (Ed.). *Constructivism in education: opinions and second opinions on controversial issues* (pp. 1-18). Chicago: University of Chicago Press.

Puchner, L. D., & Taylor, A. R. (2006). Lesson study, collaboration, and teacher efficacy: stories from two school-based math lesson study groups. *Teaching & Teacher Education: An International Journal of Research and Studies, 22*(7), 922-934.

Ray-Taylor, R., Baskerville, S., Bruder, S., Bennett, E., & Schulte, K. (2006). 6 challenges are key for high-performing schools that aim to achieve more. *Journal of Staff Development, 27*(2), 22-27.

Renshaw, P. T. (1992, November). *The sociocultural theory of teaching and learning: Implications for the curriculum in the Australian context.* Paper presented at the Twenty-Second Annual Conference of the Australian Association for Research in Education, Deakin University, Geelong, Victoria. Retrieved April 15, 2006, from webpages.charter.net/schmolze1/vygotsky/renshaw.html

Rogoff, B. (1990). *Apprenticeship in thinking: Cognitive development in social context*. New York: Oxford University Press.

Rogoff, B. (2003). *The cultural nature of human development.* New York: Oxford University Press.

Romberg, T. A., & Kaput, J. J. (1999). Mathematics worth teaching, mathematics worth understanding. In E. Fennema & T. A. Romberg (Eds.), *Mathematics classrooms that promote understanding* (pp. 3-18). Mahwah, NJ: Erlbaum.

Schoenfeld, A. H. (2002). Making mathematics work for all children: Issues of standards, testing, and equity. *Educational Researcher, 31*(1), 13-25.

Scribner, S. (1985). Vygotsky's uses of history. In J. V. Wertsch (Ed.), *Culture, communication, and cognition: Vygotskian perspectives* (pp. 119-145). Cambridge, UK: Cambridge University Press.

Secada, W.G., & Berman, P. W. (1999). Equity as a value-added dimension in teaching for understanding in school mathematics. In E. Fennema & T. A. Romberg (Eds.), *Mathematics classrooms that promote understanding* (pp. 33-42). Mahwah, NJ: Erlbaum.

Smith-Adcock, S., Daniels, M. H., Lee, S. M., Villalba, J. A., & Indelicatto, N. A. (2006). Culturally responsive school counseling for Hispanic/Latino students and families: The need for bilingual school counselors. *Professional School Counseling, 10*(1), 92-101.

Solomon, R. P., Portelli, J. P., Daniel, B., & Campbell, A. (2005). The discourse of denial: How white teacher candidates construct race, racism, and "white privilege." *Race, Ethnicity, and Education, 8*(2), 147-169.

Stepanek, J., Appel, G., Leong, M., Mangan, M. T., & Mitchell, M. (2007). *Leading lesson study: A practical guide for teachers and facilitators.* Thousand Oaks, CA: Corwin.

Stigler, J. W., & Hiebert, J. (1999). *The teaching gap: Best ideas from the world's teachers for improving education in the classroom*. New York: The Free Press.

Taylor, A. R., Anderson, S., Meyer, K., Wagner, M. K., & West, C. (2005). Lesson study: A professional development model for mathematics reform. *Rural Educator, Winter*, 17-22.

Urbansky, A., & O'Connell, C. (2003). *Transforming the profession of teaching: it starts at the beginning.* Paper commissioned for NCTAF's National Summit on The First Three Years of Teaching. Retrieved November 1, 2007, from http://www.nctaf.org/strategies/support/continuous-prof-growth/transforming-teaching.htm

U.S. Census. (2000a). *Racial and ethnic classification used in Census and beyond*. Retrieved October 16, 2007, from http://www.census.biz/population/www/socdemo/race/racefactcb.html

U.S. Census. (2000b). *Racial and ethnic classification used in Census 2000 and beyond.* Retrieved October 16, 2007, from http://www.census.gov/population/www/socdemo/race/racefactcb.html

Utah State Office of Education (USOE). (2007). Utah performance assessment system for students. Retrieved on June 1, 2008, from http://results.schools.utah.gov/upass

Van de Walle, J. A. (2001). *Elementary and middle school mathematics: Teaching developmentally*. New York: Longman.

Vygotsky, L. S. (1978**).** *Mind in society: The development of higher psychological processes.* Cambridge, MA: Harvard University Press.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*, Cambridge, MA: Cambridge University Press.

Wertsch, J. V. (1985). *Vygotsky and the social formation of mind*. London: Harvard University Press.

Wiburg, K., & Brown, S. (2007). *Lesson study communities: Increasing achievement with diverse students.* Thousand Oaks, CA: Corwin.

Wiggins, G. P., & McTighe, J. (1998). *Understanding by design.* Alexandria, VA: Association for Supervision and Curriculum Development.

Yin, R. K. (1988). *Case study research: Design and methods*. Thousand Oaks, CA: Sage.

Yin, R. K. (2003). *Applications of case study research*. Thousand Oaks, CA: Sage.

APPENDICES

APPENDIX A

Observation Protocol

Lesson Study Observation

Date of Observation_____ Name of Observer _____

Lesson topic _____

Number of students _____ Gender male___ female ___

Students from ethically diverse background (estimation) _____

Seating arrangements

Additional comments

Time	Lesson Steps and Activities	Students: Actions and Responses	Teacher: Actions and Responses	Assessment; Reflection
	Introduction			

Time	Lesson Steps and Activities	Student Activities and Responses	Teachers Actions and Responses	Evaluation and Reflection
	Lesson			
	Closure/Summary			

APPENDIX B

Lesson One Worksheets

WHAT are fractions REALLY
NAME_____
HOUR_____

EXAMPLE			
	Rule:	Rule:	Rule:

What is a fraction?

1).

2).

3).

4).

5).

6).

Fractions worksheet

Number of wholes	**Wholes divided evenly**	**How much of a whole does each person get**	**Actual fraction**	**Interpretation**

APPENDIX C

Lesson 2 Experimental Probability Lab Worksheet

Experimental Probability Lab

1. What is your name? _____What hour are you in? _____

Go to the assigned area and complete the following information at each station as a ratio of experienced outcomes to total sample space.

Dice: Roll the dice 20 times and record your results.

#	Tally
1	
2	
3	
4	
5	
6	

1.What is the experimental probability of rolling a 1?

2. What is the experimental probability of rolling a 5?

3. Do your answers have to be the same in experimental probability? Why?

Blocks: Select 20 blocks from the bag replacing each block after it has been recorded before drawing again.

Color	Tally
Blue	
Yellow	
Red	
Green	

1. What is the experimental probability of drawing a blue block?
2. What is the experimental probability of getting a green block?
3. What is the experimental probability of drawing a red block?

4. If you knew there were 20 blocks in the bag and had to guess how many of each color were in the bag, what would you guess?

Blue =
Yellow =
Red =
Green =

Coins: Flip the coin twenty times and record your results

Result	Tally
Red	
Yellow	

1. What is the experimental probability of getting a yellow?

2. What is the experimental probability of getting a red?

3. What is the difference between your two answers, and why is there a difference?

Cards: Select twenty cards one at a time replacing them after recording your results.

Color	Tally
Blue	
Yellow	
Red	
Green	

1. What is the experimental probability of drawing a red card?

2. What is the experimental probability of drawing a yellow card?

3. What is the difference of your two answers?

4. If you knew that there were 20 cards in the pile and had to guess how many cards of each color there were, what would you guess?

Blue =
Yellow =
Red =
Green =

Spinner: Spin the spinner 20 times and record your results.

#	tally
1	
2	
3	
4	
5	
6	

1. What is the experimental probability of getting a 2?

2. What is the experimental probability of getting a 6?

3. What is the difference of your two answers?

4. What is the difference between your two answers, and why is there a difference?

CURRICULUM VITAE

VESSELA ILIEVA

763 East 1200 North #C-2
Logan, UT 84341
435-797-6702
vessela.ilieva@aggiemail.usu.edu

EDUCATION

Ph.D., Curriculum and Instruction. Emphasis: Mathematics Education.
Utah State University, Logan, UT. Expected July 2008.
Dissertation: Transforming Teachers' Knowledge and Skills: Lesson Study in Mathematics Instruction Sensitive to Diverse Learners at the Middle Level.
Advisor: Dr. Jim Barta.

Professional Educator License. Endorsement: Mathematics Level 4.
Utah State Office of Education, 2005.

Master of Second Language Teaching. Emphasis: ESL and Russian Language.
Utah State University, Logan, UT, 2005.

Master of Science, Electronics Engineering. Emphasis: Radio and TV Engineering.
Technical University, Sofia, Bulgaria, 1990.

EDUCATIONAL HIGHLIGHTS

Second Bachelors degree coursework completed, Mathematics Education.
Utah State University, Logan UT, 2003.

Ph.D. level research program participant, Engineering. Emphasis: Satellite Communications. Scientific Research Institute of Telecommunications, Sofia, Bulgaria, 1993.

SCHOLARLY INTERESTS

Mathematics Education in a Global World
Equity in Mathematics Teaching and Learning
Mathematics Teachers Professional Development
Mathematics Teachers Preparation and Education

TEACHING EXPERIENCE

Graduate Instructor, Department of Elementary Education, Utah State University, Fall 2007. Course Taught: ELED 4060: Mathematics Methods for Elementary Teachers.

Mathematics Teacher, Fast Forward Charter High School, Logan, UT, 2004-2006.

- Implemented school wide math student assessment
- Implemented technology-based supplementary math instructional and assessment resources allowing for individualized math learning and teaching

Adjunct Lecturer, Russian Language and Culture, Department of Languages, Philosophy, and Speech Communication, Utah State University, 2003-2004.

RESEARCH EXPERIENCE

Research Assistant, Department of Instructional Technology, Utah State University.
Worked on a NSF funded, STEM focused grant developing a computer-based math learning program for students underrepresented in STEM. Assisted with organization and implementation of the study in schools across Utah.

Research Assistant, Department of Engineering and Technology Education, Utah State University.
Worked on a STEM related grant funded by NSF. Assisting in development and implementation of a culturally responsive community based professional development model for elementary math and science teachers of American Indian students

Research Assistant, Department of Elementary Education, Utah State University.
Assisted with design, implementation, and analysis of a research study exploring the link between teachers' use of ESL instructional strategies and the math achievement of ethnically diverse students.

SUPERVISORY EXPERIENCE

Supervised six elementary education pre-service teachers during their student teaching experience for the Department of Elementary Education at Utah State University, Spring 2008.

Supervised five pre-service elementary education teachers during their five-week long practicum, Fall 2007.

Assisted Dr. Jim Barta with practicum supervision of ten pre-service teachers placed in local schools, Fall 2006 and Spring 2007.

RELATED PROFESSIONAL EXPERIENCE

Instructional Architect Trainer, 2007-2008. Providing training with the Instructional Architect web-based teaching tool for pre-service mathematics teachers. Initiating contacts, arranging school visits, and delivering presentations to recruit for future Instructional Architect training.

Multicultural Mathematics Workshop Presenter, Summer 2006 and Summer 2007. Assisted Dr. Jim Barta; prepared and presented content for the workshop, assisted participants with activities and projects.

Blackboard Vista Course Developer, Summer 2007 and Fall 2007.
Developed online course activities and content for the ELED 4060 Math Methods for Elementary Teachers course.

Presenter, Research for Classroom Teachers, Summer 2007. Delivered an in-class presentation to graduate students, assisted in proposal writing and revising as required for the class.

Research Consultant, 2005-2006. Content writing consultant for an NSF funded grant on pedagogical agents as learning companions (PALs). Responsible for writing the content and speech for the pedagogical agents. Cooperating teacher for project implementations.

TEACHING CERTIFICATION

Professional Educator License, State of Utah. Endorsements:

- Mathematics Level 4, State of Utah
- English as a Second Language, State of Utah
- Russian Language, State of Utah

Engineering and Technology Education Teaching Credentials, Bulgaria

PROFESSIONAL SERVICE

Assisted with Utah Council of Teachers of Mathematics (UCTM) regional conference planning and organization, Logan, UT, September 2007.

Participated in planning the 2008 National Council of Teachers of Mathematics (NCTM) annual meeting in Salt Lake City, UT.

SUBMITTED PUBLICATIONS

Ilieva, V. (2007 - under review). *An exploration of the effects of community-inspired professional development on teachers' practices at one alternative high school.* A manuscript submitted for publication, Journal of Teacher Education.

PRESENTATIONS

Ilieva, V., & Pray, L. (2008). *Investigating the link between math teachers' use of ESL strategies and student achievement.* Paper presentation at the Annual AERA Meeting, New York, NY.

Ilieva, V., Becker, K., Barta, J., Monhardt, R. (2008). *Using community advisory panels to develop a STEM professional development model for teachers of American Indian Students.* Paper presentation at the UATE Annual Conference, Salt Lake City, UT.

Kim, Y., Xu, B., Ilieva, V., Wei, Q., Ko, Y. (2008). *A virtual peer encouraging girls and minorities to improve their math self-efficacy and math attitudes.* Poster presentation at the Annual AERA Meeting, New York, NY.

Becker, K., & Ilieva, V. (2008). *Using community advisory panels to develop a STEM professional development model for teachers of American Indian Students.* Paper presentation at the ASEE 2008 Annual Conference, Pittsburgh, PA.

Ilieva, V., & Barta, J. (2007). *Experience ethnomathematics: mathematics and culture.* A presentation at the Utah Council of Teachers of Mathematics Conference, Logan, UT.

Kim, Y., Wei, Q., Xu, B., Ko, Y., & Ilieva, V. (2007). *MathGirls: increasing girls' positive attitudes and self-efficacy through pedagogical agents.* Nominated for the *Best Paper Award* at the 13th International Conference on Artificial Intelligence in Education (AIED 2007): Los Angeles, CA.

GRANTS

National Education Association Learning and Leadership Grant, April 2007 ($ 5000, not funded). Submitted with Dr. J. Barta to fund a lesson study professional development for mathematics teachers of diverse students.

National Council of Teachers of Mathematics Grant, August 2007 ($ 2000, not funded). The grant supports attendance and professional development at the 11th International Congress on Mathematical Education - Monterrey, Mexico in 2008.

AWARDS

Graduate Teaching Assistant of the Year, 2007-2008. Department of Elementary Education, Utah State University, Logan, Utah.

Nominee, Robins Award, 2008. Nominated in the Graduate Research Assistant category. Utah State University, Logan, Utah.

PROFESSIONAL MEMBERSHIP

American Educational Research Association
National Council of Teachers of Mathematics
National Association for Multicultural Education
North American Study Group of Ethnomathematics
Utah Council of Teachers of Mathematics
Utah Association of Teacher Educators

HONORS

Phi Kappa Phi Honor Society
Golden Key International Honor Society
T. H. Bell Teaching Incentive Loan Recipient

LANGUAGES

Bulgarian
English
Russian