TEACHERS' BELIEFS REGARDING EFFECTIVE TEACHING STRATEGIES FOR AMERICAN INDIAN STUDENTS IN MATHEMATICS

by

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This dissertation has been read by each member of the dissertation committee and has been found to be satisfactory regarding content, English usage, format, citation, bibliographic style, and consistency, and is ready for submission to the Division of Graduate Education.

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Raquel Vallines Mira

July 2008

DEDICATION

This work is dedicated to my parents who are responsible for anything that is good in my character including the stubbornness needed to finish a project like this. Thank you for always believing in me. I owe you everything I am and everything I will be.

Mama, now I am done!

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ABSTRACT

Extensive research has been conducted on teaching strategies that are effective for American Indians in mathematics. Despite the variety of cultural, linguistic, socioeconomic, and geographic factors influencing student learning within and among American Indian communities, common characteristics of learning styles and effective teaching practices have been identified. Though the wording in each definition varies, research based on a variety of theoretical frameworks and using a variety of methodologies and instruments suggests that among American Indian students, there is a tendency to learn better when the following three strategies are used: contextualization, modeling and demonstration, and joint productive activity. Despite the general agreement in education research that the beliefs that teachers hold about mathematics teaching and learning greatly impact their instructional decisions in the classroom, few, if any, of those studies have examined teachers' beliefs regarding effective strategies for American Indians in mathematics.

The main purpose of this study was to add the voices of four teachers to the research community conversation about effective teaching strategies for American Indians in mathematics. Two elementary and two high school teachers from two schools in Montana were selected for this study for their experience with and commitment to the mathematics education of American Indian students. Two are American Indians and two are White. Using a combination of classroom observations and a modification of videoclip interviews, the beliefs of the four teachers were identified with particular focus on the three teaching strategies mentioned above. The study shows that teachers' definitions of research-based strategies often differ from those intended by the research. Teachers' views about these strategies seemed to be idiosyncratic to individual teachers and appeared to be shaped by multiple lenses. In this study, some of those lenses emerged including, among others, school structures and teachers' cultural backgrounds. In light of the results of the study, future efforts for constructive bi-directional communication between the research community and practitioners are recommended.

CHAPTER 1

INTRODUCTION OF THE STUDY

Current and traditional teaching strategies have failed to meet the needs of many American Indian students in mathematics (Indian Nations at Risk Task Force, 1991; for data in Montana check: www.opi.mt.gov/pdf/indianed/IEFADataFactSheet.pdf). Extensive research on best teaching practices for American Indian students has been done and is still being done to find teaching strategies that might help improve the learning of mathematics for American Indians in schools. Despite the variety of cultural, linguistic, socioeconomic, and geographic factors influencing student learning within and among American Indian communities, common characteristics of learning styles and best teaching practices have been identified (Lipka, 2002; Hilberg & Tharp, 2002; Hilberg et al., 2002; Morton et al., 1994; Tharp et al., 1994; More, 1987). Despite all these efforts, mathematics education is still failing American Indian students. In Montana, for example, in the mathematics section of the 2005-2006 School-Level Criterion-Referenced Test (Montana Office of Public Instruction, http://www.opi.mt.gov), only 33% of the American Indian students were rated as proficient or above, compared to 64.6% of the white students. There could be many explanations for such a gap, but a review of the literature devoted to finding effective teaching strategies for American Indians in mathematics seems to be an important piece of the puzzle.

Effective Teaching Strategies for American Indians in Mathematics

Extensive research has been conducted trying to answer the question of what are effective strategies for teaching mathematics to American Indians/Alaskan Natives. Despite the variety of cultural, linguistic, socioeconomic and geographic factors affecting different American Indian groups, common characteristics of effective teaching practices have been identified (an in-depth review of this literature will be presented in the next chapter). The Center for Research in Education Diversity and Excellence (CREDE), for example, has identified seven standards for American Indians in mathematics (Hilberg et al., 2002). The seven standards are:

- Standard I : Teachers and Students Producing Together
- Standard II: Developing Language and Literacy Across the Curriculum
- Standard III: Making Meaning - Connecting School to Students' Lives
- Standard IV: Teaching Complex Thinking
- Standard V: Teaching Through Conversation
- Standard VI: Encouraging Students' Decision Making
- Standard VII: Learning through Observation.

Like CREDE, other groups, using research based on a variety of theoretical frameworks and using a variety of methodologies and instruments, have found several teaching strategies that seem to be more effective when teaching mathematics to American Indian students. The number and type of strategies identified by each research group varies. Three of those teaching strategies identified by the research as effective for teaching

mathematics to American Indian students have been selected as the focus of this study. The three strategies are:

- *Contextualized instruction* (Contextualize teaching and curriculum in the experiences and skills of students' homes and communities);
- *Teaching through modeling and demonstration* (Coordinate verbal and physical modeling to make visible and explicit thinking strategies that experts use in particular domains); and
- *Joint productive activity* (Teachers and students working together for a common product or goal).

The reasons for selecting only three are more than just practicality. In my review of the literature on effective strategies for American Indians in mathematics, I have found these three strategies form the core of the intersection set of all the studies. They are also the strategies with the largest amount of research supporting their effectiveness with American Indian students (see literature review in Chapter 2 for an extensive review of the research).

For those familiar with the research on American Indian learning styles, there is one teaching strategy that might seem to be missing from my selection, holistic instruction. According to research, American Indian students seem to learn more effectively if taught in a holistic manner (Backes, 1993; Davidson, 1992; Fox, 1988; Florey, 1986; Hilberg, Doherty, Dalton, Youpa, & Tharp, 2002; Hilberg & Tharp, 2002; Kamphaus, Kaufman, & Reynolds, 1985; Krywaniuk, 1974; Macias, 1989; More, 1987, 1993; Pewewardy, 2002; Tharp, 1994). In holistic instruction students are initially presented with a view of the larger context so that the meaning of concepts can be derived from their relationship to that

context. Much classroom instruction is dominated by an analytic presentation of information, with little consideration of the overall context or meaning (Gilliland, 1988; Henderson & Landesman, 1995). Typical mathematics instruction assumes that students will develop an understanding of concepts from their relationship to one another, not the larger context. American Indian students, on the other hand, may prefer or require an understanding of the whole picture before proceeding to the details (Hilberg et al., 2002). In order to reach these global thinkers, teachers should present an overview of the whole concept before addressing the details and discuss the overarching themes and relate them to the students' common knowledge (Hilberg & Tharp, 2002).

During the design of my study I first thought of including holistic instruction as one of the strategies to guide my study. However, I decided to drop it at the final stages of my design. The reason for that decision was that, despite all the literature supporting the idea that American Indians have a holistic style of learning, research that tests whether holistic instruction is or is not an effective strategy when teaching American Indian students is very scarce. Therefore, "holistic teaching" as an instructional model is not clearly defined in the literature and there is not strong support for its efficacy with American Indian students. On the other hand, I believe the general concept of holistic instruction is often reified in the other three strategies selected for this study. Therefore, I am not completely disregarding the holistic learning style of American Indians in my study. An example of how contextualization is closely tied to the holistic learning patterns of American Indian children is given by Moore (1994) who used an informal group class discussion to contextualize a lesson in algebra for Navajo college students. When teaching a method for solving quadratic

equations, he initiated the lesson with a discussion of a problem situation in which obtaining a solution requires solving a quadratic equation. He posed the following problem: “If you throw a baseball straight up, when will it be fifty feet high?” (p. 10). Students asked questions such as, “How fast was the ball thrown?” Moore endured those remarks and persisted with his initial question until one student observed: “But there will be two times when the ball is fifty feet high, one with the ball going up and a second when the ball comes down.” The class then discussed models of equations with more than one solution (Moore, 1994 as cited in Hilberg et al., 2002). Often, as we can see in this example, contextualization can address the holistic learning patterns of American Indian students.

Problem Statement

Most of the studies on effective strategies for American Indians in mathematics have been done based on previous research on the learning styles of American Indians. Using those theories and, in some cases, the input of experts and members of the community involved in the study, researchers have developed units (or entire curricula) that were later tested to prove their hypothesis. Some have included Native teachers in the conversation and development of those curricula, but in most cases teachers were asked for their experiences as learners as it related to their culture. There is a general agreement in educational research about how the beliefs that teachers hold about mathematics, teaching and learning greatly impact their instructional decisions in the classroom (Calderhead, 1996; Pajares, 1992; Thompson, 1992; Tillema, 2000; Shavelson & Stern, 1981; Speer 2001). Despite that, not many, if any, of the studies on strategies for American Indians in mathematics have asked

teachers what their teaching experiences have taught them about effective strategies for their American Indian students in mathematics. My study seeks to add their voices to the conversation.

Purpose of the Study and Research Questions

The main purpose of this study is to add the voices of four teachers to the conversation about effective strategies for American Indians in mathematics. I intended to do this by identifying the beliefs of these four teachers with particular focus on those three teaching strategies identified for this study while giving them the chance to also express their views about other practices that are of importance to them. The research questions are:

Question #1

What are the beliefs of four teachers who work with American Indian students in mathematics regarding the following teaching strategies identified by research as effective teaching strategies for American Indians in mathematics:

- Contextualized instruction;
- Teaching through modeling, and demonstration; and
- Joint productive activity?

Question #2

What concordances and discordances exist between the beliefs of teachers who work with American Indian students in mathematics and research findings on effective teaching practices for American Indians in mathematics?

Significance of the Study

This study will articulate the beliefs of four experienced teachers on which strategies are effective for their American Indian students in mathematics. In-depth investigation into the experiences and beliefs of individual teachers may offer a window into the complex phenomenon of teachers' strategy choice. In particular, the study will describe the teachers' perspectives on the three strategies identified by the research as effective for American Indians in mathematics. This will add teachers' voices to the conversation on effective practices for American Indians, which may shed some new light to the research.

The study will also help identify whether a gap exists between research and practice regarding effective teaching strategies for American Indians in mathematics and, if so, identify what are some of the reasons for those differences.

The Meaning of Effective Teaching Strategy

What does it mean that a teaching strategy is effective? Looking at my review on effective strategies for American Indians in mathematics (Chapter 2), I noticed two slightly different meanings to the word "effective." On one side there are the studies that consider effective a strategy that improves students' motivation, keeps students on task, promotes students' participation and enthusiasm, etc. Good examples of this are Lipka et al. (2005) and Schaufele and Srivastava (1995). In the case of Ms. Sharp (Lipka et al., 2005), the teacher, by using modeling instruction, gets students' attention back and manages to get them focused and on task. In the other example, when Schaufele started teaching in a new school, he found himself forced to change the topic of a previously successful algebra unit

to relate with the context of the new students in order for the students to react positively to the activities. On the other side there are studies that refer to a teaching strategy as effective if it improves student achievement (Lipka & Adams, 2004; Rickard, 2005; and Morton et al., 1994). Improvement is measured most of the time by comparing students' scores on pre- and post-tests (Lipka & Adams, 2004; Rickard, 2005). Lipka's work in Alaska (2004) with the Math in Cultural Context units is a good example of this. Lipka also talks about closing the achievement gap as he compares gains in achievement of students from rural and urban schools (Lipka & Adams, 2004). In this study I considered both types of improvement to be evidence for effectiveness. I also explored and considered teachers' own definitions of effective teaching strategy.

Native American or American Indian

In the following chapters I use the terms American Indian, Native, and Native American interchangeably based upon the rationale used by Lomawaima and McCarty (2006) in their book *To Remain an Indian*:

> We use the terms American Indian, Native, Native American interchangeably to refer to peoples indigenous to what is now the United States. Personal identity among Native peoples is often layered: rooted in a particular tribe; encompassing a sense of shared American Indian identity; and expressed in intersecting layers of tribal, state, and national citizenship. We use the term American in a national sense, referring to the United States of America and its citizens, recognizing that there is a larger understanding of the term referring to Latin American nations and peoples (Lomawaima, & McCarty, 2006).

Background for the Study Context

The Center for Learning and Teaching in the West

Funded by the National Science Foundation, the Center for Learning and Teaching in the West (CLTW) is a consortium of five universities collaborating with tribal colleges and public school systems in Montana, Colorado and Oregon. The Center brings the varied expertise of scientists, mathematicians, and educators to address current challenges in understanding and improving student learning and achievement in science and mathematics from middle school through college. Work includes fundamental research and related activities focused on serving high-need populations in urban and rural settings. At Montana State University, CLTW facilitates professional development for teachers on two reservations in Montana as well as in the two nearest off-reservation districts. The main goal for all the different opportunities offered by the CLTW professional development is to build a professional learning community of mathematics teachers from the area. The teachers involved in this study attended three different extended CLTW professional development opportunities that will be described in Chapter 3.

The Teachers and the Schools

Four teachers were involved in this study, two in each of two schools: Burton Intermediate and Mountain High School. Ronda and Laura teach fourth and fifth grade in Burton Intermediate. Burton is an off-reservation border town. Burton Intermediate offers third, fourth, and fifth grades; 59.0% of the student population is American Indian and 33.1% is white. Ronda is American Indian; she was born and still lives on the reservation.

Laura is white and lives 50 miles away from Burton in the largest city in the state. She drives back and forth to school everyday. They are both young teachers and have always taught in schools with high percentages of Native American students among the student populations. Julia and Teresa both teach at Mountain High School, a school where 100% of the student population is American Indian. Mountain is the largest town on the reservation. Teresa is American Indian and lives in Mountain while Julia, who is white, lives there during the week and goes back home to a different town on weekends. Both Burton and Mountain belong to the same county, one of the poorest in the United States.

Research Methodology

The nature of this study, an in-depth investigation into the beliefs and experiences of individual teachers, suggested a qualitative case study design. Johnson (1980) describes the case study as "unique in its potential for generating hypothesis or useful detailed information about learning or the instructional process." The study is a combination of exploratory and comparative case studies (Yin, 1994; Creswell, 1990; and Hawthorne, 1992). First I will present the individual portraits of the beliefs of four teachers regarding effective teaching strategies for American Indian students in mathematics. Each provides a description of their beliefs regarding three strategies identified by the research as effective, as well as other strategies of importance for the teacher. I also attempted to address some of the factors that might shape those beliefs and the rationales behind those beliefs. This first part corresponds with an explanatory case study. Finally, in a comparative case study style, I will compare and contrast the four portraits in terms of beliefs and try to come up with a

fair representation of the group. Finally, I compared teachers' beliefs regarding strategies to contextualize instruction, model mathematical processes, and engage students in joint activities with the research-based definitions of *contextualized instruction*, *teaching through* modeling and demonstration, and *joint productive activity*. I looked for concordances and discordances and sought a rationale behind them. My approach to find the concordances and discordances between the teachers' beliefs and the research theories resembled grounded theory. In grounded theory, the goal is to generate a substantive theory (Creswell, 1998), to use "a systematic set of procedures to develop an inductively derived grounded theory about a phenomenon" (Strauss & Corbin, 1990, p. 24). A grounded theory study aims to find a theory that accounts for the data, instead of setting out to test a hypothesis. Categories and explanations gradually emerge and evolve from the data as the study proceeds (Glaser, 1992 and Creswell, 1998). For this study I did not have any hypothesis on whether concordance or discordance exists between the teachers' beliefs and the research theories, or on what could be the rationale behind those concordances and discordances. They all emerged from the data collected in the study.

The methodological approach for data collection will be a modified version of videoclip interviews (Speer, 2001) as a way of studying teachers' beliefs on effective teaching strategies for American Indian students in mathematics. Based in part on other researchers' use of "videoclubs" as a professional development activity and as a source of data on teacher cognition (Frederiksen et al., 1998; Nathan et al., 1998; Sherin, 1996, 2002), Speer (2001) designed a method called *videoclip interviews*. Videoclip interviews seek to achieve a better shared understanding for researchers and teachers; to improve the accuracy

of teachers' belief attributions; and to facilitate data collection that focuses on the context of the study (Speer, 2002).

Limitations of the Methodology

The methodology chosen for this study may pose three primary caveats for the reader. The first involves the generalizability of the results; the second relates to the degree to which I can actually, with the methodology chosen, correctly interpret the participants' comments regarding their beliefs on effective strategies; finally, the third caveat has to do with the positionality of the researcher relative to the teachers and how the relationship might influence my interpretation of some of the teacher comments and/or behaviors in the classroom.

For this study to be viewed as "valid," I will need to use methods that will help minimize researcher-teacher misunderstandings and false attributes of beliefs. Also a rich description of teachers' contexts, actions in the classroom, and interview answers and conversations regarding their beliefs will help minimize the "researchers' interpretation factor" (Hawthorne, 1992) and help the reader recognize aspects of these individuals in other teachers.

In Chapter 3, I provide a fuller description of the methodological choices for my research, as well as a discussion of the limitations of the study.

CHAPTER 2

REVIEW OF THE LITERATURE

This study primarily exists at the intersection of two areas of research: (1) effective teaching strategies for American Indians in mathematics; and (2) mathematics teachers' beliefs and the methodology used in the research to investigate them. Therefore, this chapter is organized in two parts. The first part is a literature review of the research on effective teaching strategies for American Indians in mathematics. As mentioned in the previous chapter, the teaching strategies discussed in this study are part of the core intersection of all the studies on effective practices and the ones with the largest volume of research supporting their effectiveness with American Indian students. The first section will help the reader understand the context in which I looked at teachers' beliefs in this study. In the second part of the chapter, a review of the methodology used in the study of mathematics teachers' beliefs is presented. That section will help the reader understand the choice of the methodology of this study as well as the importance of looking at teachers' beliefs.

Teaching Strategies for American Indians in Mathematics: Review of the Literature

By the 1970s, educators and researchers confirmed that cultural and ethnic factors influence student learning styles (More, 1987). Interest in culturally responsive teaching grew during the late 1980s and early 1990s as a result of rapidly rising diversity in U.S. classrooms and concern over the lack of success of many ethnic/racial minority students

despite years of education reform (Pewewardy & Hammer, 2003). Because current and traditional teaching strategies have failed to meet the needs of many American Indian students (Indian Nations at Risk Task Force, 1991; for data in Montana check: www.opi.mt.gov/pdf/indianed/IEFADataFactSheet.pdf), extensive research on best teaching practices for American Indian students has been done and is still a growing field in educational research.

Within and among American Indian communities, there are a variety of cultural, linguistic, socioeconomic, and geographic factors influencing student learning. Therefore, a specific learning style will not be representative of all American Indian students. However, despite the variety, common characteristics of learning styles and effective teaching practices have been identified (Lipka, 2002; Hilberg & Tharp, 2002; Hilberg et al., 2002; Morton et al., 1994; Tharp et al., 1994; More, 1987). Though the wording in each definition varies, research based on a variety of theoretical frameworks and using a variety of methodologies and instruments suggests that American Indian and Alaska Indian students learn better (a) when teaching is contextualized; (b) when collaboration among students and teachers is fostered; and (c) when modeling and demonstration are used and reflection is encouraged. In the next pages a review of the literature regarding those three strategies will be presented.

Contextualization: Defining Characteristics

An activity is contextualized when students' knowledge from home, school, or community is actively incorporated into the lesson (Tharp, 1997). Many educators and researchers agree that instruction is more effective when contextualized in students' personal experiences and knowledge (D'Ambrosio, 1985; Davidson, 2002; Bishop, 1988; Hilberg et

al., 2002; Hilberg & Tharp, 2002; Pewewardy, 2002; Tharp, 1997 & 1989; Trumbull et al., 2002; Lipka et al., 2005a). Connecting educational content to students' personal lives and the values and traditions of the local community, and providing instructions in familiar, everyday contexts, about which students have previous knowledge, enable students to make sense of instruction and to construct new knowledge accordingly (Tharp, 1997; Trumbull et al., 2002). Great efforts have been made to reform mathematics education to fulfill the need to connect school mathematics with students' own experience and intuitive knowledge (Trumbull et al., 2002). An overarching goal of all the National Council of Teachers of Mathematics (NCTM) standards, for example, is to integrate mathematics into contexts that give practical meaning to its symbols and processes. Teachers are encouraged to pose tasks that exhibit sensitivity to and draw upon students' diverse experiences and dispositions (NCTM, 1991). The *Professional Standards for Teaching Mathematics* states:

> Teachers also need to understand the importance of context as it relates to students' interests and experience. Instruction should incorporate real world contexts and children's experiences and, when possible, should use children's language, viewpoints, and culture. Children need to learn how mathematics applies to everyday life and how mathematics relates to other curriculum areas as well. (NCTM, 1991 p.146)

Tharp (1989) and Hilberg et al. (2002) talk about three levels of contextualization that are possible at schools. At the pedagogical level, patterns are established in the classroom of participation and discourse that are familiar to students at home and in the community. At the curriculum level, materials and skills from home and the community serve as the foundation for academic content and the development of school skills. At the policy level, the school itself is contextualized in the community and reflects its beliefs, values, and goals. When I use the term *contextualization*, I am mostly referring to the second

level, the curriculum level. On the other hand, the pedagogical level involves all the other teaching strategies discussed in this chapter (modeling and joint productive activity).

Mathematics is a product of culture, and the mathematics taught in schools represents a particular cultural orientation (Trumbull et al., 2002). American Indian students' intuitive and experience-based mathematical knowledge is not usually included in schools. In most cases, school mathematics is not contextualized in a way that links to the Indian students' experiences at home and their community (Trumbull et al., 2002). For Indian students, especially those living and studying on reservations (Davidson, 2002), this cultural disconnection poses additional obstacles for achievement in mathematics (Barta, et al., 2001; Leap, et al., 1982; Pewewardy, 2002).

Using a cross-cultural perspective, researchers (Leap et al., 1982) studied the "math avoidance syndrome," which had reached crisis proportions among American Indians at two elementary schools on Utah's Northern Ute Reservation and Wisconsin's Oneida Indian Reservation in 1980. Researchers gathered data by observing mathematics instruction at the schools and by interviewing parents, teachers, tribal officials, and a group of students from third and fourth grade classrooms. They also discussed with tribal elders each tribe's style of computation and problem solving. Results showed that, contrary to widely held beliefs, neither degree of traditionality nor gender of student served as an accurate predictor of student mathematical attainment or interest in mathematics. Perceived conflicts between school and home regarding function and purpose of education, social organization of mathematics lessons, incompatibility of classroom management styles, student-preferred

patterns of self-dependence, familiarity with the tribe's traditional enumeration system, and other factors were found to be more significant variables.

Traditionally, the mathematics taught in schools seldom includes clear connections with tribal culture (Slapin, 1998; Pewewardy, 2002). Consequently, many students "view mathematics as a spectator sport rather than one in which they can participate" (Pewewardy, 2002). Culturally contextualized curricula connect the students with their heritage. It is the bridge between their world on the reservation or in their community and the different world that may often exist in the school setting (Barta et al., 2001).

For the mathematics curriculum to be enriched, teachers need to hold an attitude of respect for cultural differences, know the cultural resources their students bring to class, and be skilled at tapping students' cultural resources in the teaching-learning process (Davidson, 2002; Pewewardy & Hammer, 2003). According to Smith (1991 as cited in Pewewardy & Hammer, 2003), culturally responsive teaching uses the child's culture to build a bridge to success in school achievement. Building such a bridge requires a degree of cultural literacy. Some research has shown that where the students and teachers share the same culture, learning is enhanced (McCarty & Watahomigie, 1999; Erickson & Mohatt, 1982). If teachers are not familiar with their American Indian students' culture, help could be sought from leaders in the community, other native authorities, or experts in Indian education. Teachers could then select culturally oriented learning activities that can be used in the study of mathematics content. Teachers should ensure that the learning activities are culturally valid for their students and educationally sound (Davidson, 2002). In a survey of 24 middle school students from a Crow Indian community, Davidson (2002) found that all the students

participated in at least one traditional cultural activity. The students were committed to such Crow cultural activities as hand games, arrow throws, star quilting, beadwork, dancing competitions, teepee rising, or making fry bread. According to Davidson, including some of these activities in the mathematics curriculum might enrich these students' sense of purpose for studying mathematics and help them to make meaningful connections between mathematics and everyday life. Of course, caution should always be taken when trying to incorporate students' culture into the classroom to avoid trivialization or misinterpretation of the students' Native culture (Davidson, 2002). This is particularly important when the teacher and the students do not share the same culture.

As mentioned before, great efforts have been made to try to contextualize mathematics to students' cultures and communities. The following provide some examples that illustrate how traditional school mathematics can be connected with the informal mathematics (Davidson, 2002) of some Native cultures.

A good example of a mathematics lesson contextualized for Plains Indian students is Britton's (1983) unit "Medicine Wheels: The Art and Culture of Planes Indian." The interdisciplinary unit for seventh grade students, involving art, social studies, and mathematics, focuses on a study of the forms, symbols, designs, and colors of the traditional art form of the Plains Indians, the Medicine Wheel. Objectives of the unit are for students to gain an understanding of the culture of the Plains Indians, to develop skills in using various tools in geometric construction, and to create "personal Medicine Wheel" designs that incorporate ideas resulting from social studies discussions. Selected passages from "Seven Arrows" by Hyemeyohsts Storm, a Northern Cheyenne, and ten pages of appended

transparency masters (from Leroy Appleton's "American Indian Design and Decoration") showing examples of medicine wheels and design details are the principal resources for the unit. Suggested activities include discussing reading passages, writing essays, creating Medicine Wheel designs by using mathematical concepts and tools and telling stories about completed Medicine Wheel shields.

Schaufele and Srivastava (1995) developed *Earth Algebra*, a college Algebra unit for students at Navajo Community College (NCC) at Shiprock, New Mexico. The goal of the unit was to "bring college algebra to life, to put it in a context that would provide real situation and familiar circumstances where mathematics could be used to solve meaningful problems and reach informed decisions" (p. 13). The algebra class uses traditional algebra topics as tools to study real-life situations, focuses on environmental issues involving water conservation, water quality, and air pollution (major concerns of the NCC community). It encourages collaborative learning, uses modern technology, and promotes development of critical thinking and decision-making skills. Students study the effects of global warming on water supplies in their region. The unit was first designed by Schaufele and Zumoff (1996) to be taught in Georgia and focused on environmental issues like energy consumption and tropical deforestation. When Schaufele tried to teach it at NCC, Navajo students did not show much enthusiasm. Not until the unit was modified to emphasize issues that related to the Navajo community did students start to react positively (Hilberg et al., 2002).

In *Adapting Yup'ik Eskimo Elders' Knowledge*, a development project funded by a National Science Foundation grant to create a supplementary elementary school mathematics curriculum, Lipka's group (2001) bridged the knowledge contained in everyday situations

in southwest Alaska with the spatial abilities required for geometry. Working collaboratively with Yup'ik Eskimo elders, teachers, mathematicians, and mathematics educators to transform the curriculum, they incorporated local knowledge into culturally based mathematics lessons (Lipka, 1998). The aim of the project was to transform the elementary school mathematics curriculum by integrating local knowledge into culturally-based lessons in mathematics. In *Elastic Geometry and Storyknifing: A Yup'ik Eskimo Example* (Lipka et al., 2001), they introduce elastic geometry, or topology, into the elementary classroom through a study connecting the intuitive, visual, and spatial components of storyknifing, which is a way of telling a story to an audience while using a storyknife. The unit connects the intuitive, visual, and spatial components of storyknifing as well as other everyday and ethnomathematical activities with mathematical reasoning. This allows teachers to adapt, enrich, and enlarge the types of problems and processes that elementary school students face when learning mathematics so they can see the relationship between their surroundings and mathematics **(**Lipka et al., 2001).

Math in a Cultural Context (MCC): Lessons Learned from Yup'ik Eskimo Elders (Lipka et al., 2005) is a series of Modules that are intended to supplement a complete K-6 mathematics curriculum and explicitly connect important mathematics with the culture and knowledge of the Yup'ik people. The modules in the MCC series are aligned with the National Council of Teachers of Mathematics (NCTM, 2000) *Principles and Standards* and incorporate substantive inquiry-oriented activities that engage students in learning about mathematical content and processes by exploring rich mathematical problems. The MCC modules situate standards-based content and pedagogy in the context of Yup'ik culture

(Lipka et al., 2005; Rickard, 2005). One of the MCC modules is *Building a Fish Rack: Investigations into Proof, Properties, Perimeters, and Area (*Adams & Lipka, 2003). The module is intended for sixth grade students. The hands-on activities related to building a fish rack for the harvest of salmon forms the basis upon which formal mathematics developed in this module.

Even though there are many great examples of contextualized mathematics for Indian students, a review of recent research provides only limited evidence that culturally based programs improve the academic performance of Indian students; research describing how this occurs also is rare (Lipka et al., 2005). In their review of culturally based education, Demmert and Towner (2003) found little empirical evidence to support what seems to be obvious contentions. Of the more than 8,000 studies Demmert and Towner reviewed, only a few used quasi-experimental designs, found statistically significant results, and involved core academic content. Of these studies, only the Yup'ik work is ongoing (Lipka & Adams 2004; Lipka, Sharp, Adams & Sharp, in press). Brenner (1998) and Doherty et al. (2002) also conducted quasi-experimental studies in core academic content areas and found statistically significant results (Lipka et al., 2005).

As mentioned above, Math in a Cultural Context (MCC) was developed from ethnographic work with Yup'ik elders and teachers. Two case studies of novice teachers, one cultural "insider" and one "outsider," illustrate how each effectively taught MCC (Lipka et al., 2005). The insider transformed her teaching by allowing student ownership through inquiry and cultural connections. The outsider deepened her mathematics content knowledge and found a good pedagogical fit through MCC. The research of Erickson and Gutiérrez

(2002) has shown repeated favorable results in implementing MCC. This research design uses both quantitative and qualitative/ethnographic methods. However, the quantitative methods do not provide insights about how curriculum is enacted, nor do they illuminate student–teacher interactions that may contribute to students' improved performance.

Rickard's (2005) case study examines a sixth-grade teacher and her students in an urban school district in Alaska, engaging in an activity from *Building a Fish Rack: Investigations into Proof, Properties, Perimeters, and Area (*Adams & Lipka, 2003). By analyzing the module, the teacher's practice, classroom discourse, and students' work, the case shows that the teacher and the MCC module supported students in developing substantive reasoning and understanding about the mathematical relationship between constant perimeter and varying area in rectangles. Comparison of students' scores on pre- and post-tests shows that the class as a whole outperformed the control group. Moreover, Alaska Native students, comprising slightly over one-fourth of the class, outperformed the control group, had gains in achievement commensurate with the entire class, and outperformed by a wide margin their Alaska Native peers in the control group. The case shows that the MCC module and the teacher's practice support improved mathematics.

Also, the study of Lipka and Adams (2004) shows that the culturally based mathematics curriculum, *Building a Fish Rack: Investigations into Proof, Properties, Perimeter, and Area,* enabled sixth grade Yup'ik students and their urban counterparts to increase their mathematical understanding of perimeter and area. The study was conducted during one semester with 258 students in 15 classes. It used a strong quasi-experimental design with random assignment. The results were based on pre- and post-test score

differences involving one urban school district, Fairbanks, and four rural school districts with approximately a 97% Yup'ik population. The study showed that the difference in test results between all treatment groups and all control groups was significant ($p<0.05$). Although the urban treatment group gained the most from this curriculum, the most important finding was that the rural treatment group outperformed the rural control group at a significant level ($p<0.05$). The study shows that the treatment effect on Yup'ik students narrows the long-standing academic gap when comparing that group's and the Yup'ik control group's relative performance against the urban control group.

Summary of Contextualization Findings

Contextualization of the mathematical content has been proven to be effective for American Indian students. In contextualized instruction, the teacher connects educational content to students' personal lives and the values and traditions of the local community, and provides instructions in familiar, everyday contexts, about which students have previous knowledge, enabling students to make sense of instruction and to construct new knowledge accordingly

Joint Productive Activity

Research indicates that American Indian students tend to favor cooperation over individual work and competition (Brown, 1980; Cajete, 1999; Dumont, 1972; Hilberg & Tharp, 2002; Hilberg et al., 2002; Lewis & Ho, 1989; Little Soldier, 1989; More, 1993; Nel, 1994; Nuby, 1995; Nuby, Ehle, & Thrower, 2001; Nuby & Oxford, 1996, 1997; Pewewardy, 2002; Riding & Read, 1996; Riding & Rayner, 1998; Scollon & Scollon, 1981; Swisher,

1990; Swisher & Deyhle, 1989; Tafoya, 1989; Walker, 1984; Ward, 1993; Wax, Wax, & Dumont, 1989; Wilcox, 1996). According to many American Indian/Alaskan Native observers, Native cultures place more value on cooperation, sharing and contributing to the group than on individual achievement (see, for example ,Brewer, 1971; Chavers, 2000; and Swisher, 1990). In traditional Native communities and homes, children usually collaborate with others to accomplish tasks and solve problems. Therefore, accomplishing tasks in collaboration with others aligns well with the "sociocultural" characteristics of the American Indian community and family. However, schools do not typically teach in this manner. Students are often expected to complete much of their work individually. Most Native students perform better when working cooperatively in groups rather than competitively as individuals because they are not accustomed to solving problems in this manner (Brewer, 1977; Hilberg & Tharp, 2002; Hilberg et al., 2002; Lockart, 1978; Swisher, 1990; Wax, 1971). There is security in being a member of the group rather than being singled out (Swisher, 1990).

According to research (for example, Hilberg et al., 2002; Tharp, 1997; Swisher, 1990; Lipka, 2005), Native children traditionally developed into competent members of their families and communities by engaging in dialogue and joint activity with more experienced members of the community. Therefore, it seems that for American Indian students, learning is optimized when experts and novices engage in dialogue while working together for a common product or goal (Tharp, 1997 in Hilberg et al., 2002). According to the first *Standard for Effective Mathematics Education for American Indian Students* (Hilberg et al., 2002) from the Center for Research on Education Diversity and Equity (CREDE), learning

is more effective when teachers and students work jointly to solve practical, real-world problems. In the call to "facilitate learning through joint productive activity among teachers and students" (Tharp, 1997), CREDE's first standard suggests that "Learning is optimized when experts and novices engage in dialogue while working together for a common product or goal" and that "learning is most effective when teachers and students work jointly to solve practical, real-world problems" (Tharp, 1997).

Educational literature often talks about the benefits of cooperative learning, not only for American Indian students but for every student. In fact, the National Council of Teachers of Mathematics (NCTM) advocates in its standards (NCTM, 1991) that mathematics classrooms should focus on problem solving involving small groups or an entire class working cooperatively. Also, the mathematics standards for National Board certification (National Board for Professional Teaching Standards, 1998) maintain that accomplished mathematics teachers "provide opportunities for students to talk with each other and work together in solving problems, recognizing that students' justifications and contributions to a group enhance their own learning" (p. 36). It is important to notice, though, that while "joint productive activity" includes student collaboration, it goes beyond students collaborating with each other. In joint productive activity, experts and novices (students and teachers or other experts) work together for a common goal.

In an ethnographic study of the Warm Springs Reservation in Oregon, Philips (1983) observed the participation/interaction of Anglo and Indian students in public school classrooms. Based on this, she identified four different participant structures used by teachers to draw out or elicit student interaction and demonstrations of their learning: (1)

whole class interaction with the teacher; (2) small group interaction with the teacher; (3) one-to-one involvement between teacher and single student, usually during desk work in which interaction is initiated by a student's raised hand or approach to the teacher's desk; and (4) student-led groups supervised by the teacher. Philips (1983) reports that Warm Springs Indian children, in contrast with Anglo children, were reluctant to participate in the first two structures; however, they were more talkative than Anglo children in the context of student-initiated verbal interaction and student-led group projects.

Brown (1979) reported that Hess' study (1974) with 481 American Indian students enrolled in grades three through eight on a Northern Plains reservation found high levels of classroom competition negatively related to the achievement of Indian students. Brown's study (1980) of cooperative and competitive behavior among Cherokee children indicates that Cherokee grade school children were more cooperative and less competitive than an Anglo comparison group. He found that competitive behavior was negatively related to measures of their school achievement.

In a study (Wauters et al., 1989) examining the results of one learning style instrument, the Productivity Environmental Preference Survey, used to evaluate 200 Alaskan high school seniors, the differences between Native and non-Native subjects were analyzed. Significant differences were found in learning styles between Native and non-Native subjects on the Persistence, Peer, Authority, Auditory, and Visual subscales. In the study the authors noticed that although both groups were well within the norm on preference for learning with peers, Native students were significantly more peer-oriented than non-Natives. The finding corroborated other research on Native students which shows that they are positively oriented

to collaborative learning and small group tasks (Philips, 1972; Johnson, Johnson, Tiffany & Zaidman, 1984). In order to support the creation of peer support networks within the classroom, small group work such as discussion circles and collaborative writing assignments can be encouraged. Peer tutoring might be a helpful strategy as well.

A good example of joint productive activity is offered by the National Board's mathematics standards (National Board for Professional Teaching Standards, 1998). In this activity the teacher engages elementary-grade students in the construction of a bar graph based on their preferences for flavors of ice cream. First, each student places a Post-it note on a prepared grid on the chalkboard, and then the students make a human bar graph using classroom floor tiles as a grid and forming lines corresponding to their favorite ice-cream flavors. In this activity each student contributes to the creation of a graph that becomes the product of this joint activity. Hilberg et al. (2002) suggest that this activity could be modified to be more culturally relevant to American Indian students, perhaps by basing it on favorite local desserts or traditional meals or on favorite community events or holidays.

Davidson (1992) also provides an excellent example of joint productive activity in which a bilingual teacher at the Crow Agency School taught students to use ratios by dividing a map of the reservation into six rectangles, assigning each portion to a group in the class. Each group enlarged its portion of the map using a scale of 3:1 after which students constructed a plaster relief model of the enlargement. The finished products were combined to form a table-sized relief map of the reservation.

Summary of Findings about Joint Productive Activity

As the studies presented in this section show, learning for American Indian students in mathematics is optimized when experts and novices engage in dialogue while working together for a common product or goal.

Teaching through Modeling and Demonstration

Research indicates that American Indian students generally exhibit a reflective learning style (Appleton, 1983; Backes, 1993; Boseker & Gordon, 1983; Brewer, 1977; Deyhle & Deyhle, 1987; Dumont, 1972; Gilliland, 1999; Hilberg et al., 2002; Hilberg & Tharp, 2002; Hilliard, 2001; Hollins, 1999; Longstreet, 1978; Nelson-Barber & Estrin, 1995; Nuby & Oxford, 1998; Pewewardy, 2002; Philips, 1983; Swisher, 1991; Tharp, Dalton & Yamauchi, 1994 in Hilberg et al., 2002; Tharp, 1997; More, 1993; Wax, Wax, & Dumont, 1964; Werner & Begishe, 1968; Wilcox, 1996). This research suggests that teachers should consider their students' learning and conversation patterns when designing their lessons. It also indicates that there are greater proportions of visual information processors among American Indian groups of students than among students from other groups, and recommends the use of modeling and demonstration when teaching mathematics to these students (Barta, 1999; Backes, 1993; Connelly, 1983; Davidson, 1992; Deyhle & Deyhle, 1987; Florey, 1986; Gilliland, 1988; Hilberg & Tharp, 2002; Hilberg et al., 2002; Lipka et al., 2005, 2006; More, 1993; Morton, Allen, & Williams, 1994; Pewewardy, 2002; Riding & Rayner, 1998; Rougas, 2000; Tharp, 1994; Tharp, Dalton, & Yamauchi, 1994 in Hilberg et al., 2002; Wickett, 1997; Wilcox, 1996).

Learning through Reflective Observation. Some students learn by observing the tasks they are to perform, referred to by Nelson-Barber and Estrin (1995) as a watch-then-do approach (Hilberg et al., 2002). A reflective type of learner completely thinks through the new learning before using it. This certainly fits with the traditional teaching styles of many American Indian cultures which encourage long periods of observation and reflection only after which performance is expected (Hilberg et al., 2002; Hilberg & Tharp, 2002; Longstreet, 1978; More, 1993; Pewewardy, 2002; Red Horse, 1980; Tharp, 1997; Wax, Wax, & Dumont, 1964; Werner & Begishe, 1968). Traditionally, American Indian/Alaska Native students have been taught at home and the community by observing parents or elders who generally teach through demonstration. Children watch and then imitate the skills. For example, the father, mother, or elder might teach the child a skill by modeling. Children are expected to watch, listen and then do. Children are allowed to develop competence before they are required to perform publicly. Evelyn Yanez, a former Yup'ik teacher says: "They [the elders] never forced us to do anything. If he wanted to learn something, he'd sit down and just watch" (in Lipka et al., 2005, p. 50).

Reflection is defined as the tendency to stop to consider options before responding, often resulting in greater accuracy in conceptualizing problems (Hollins, 1999). A reflective student does not need immediate closure. Instead, she or he is more open-oriented, delaying decision-making until all evidence is collected before coming to a conclusion or acting in response to a situation. When posed with a question or problem, reflective learners examine all sides of an issue, as well as possible implications and solutions related to the problems. Therefore, they are careful to make sure that the answer to a problem is known before

responding. It is not uncommon, therefore, for reflective students to spend much more time watching and listening and less time talking than do non-reflective students (Gilliland, 1999). There is a difference in the time intervals in which students contemplate issues before arriving at conclusions. For example, some students' conversations may have a longer "wait time" between responses. Therefore, learning may be enhanced by teachers "tuning in" to the students' rhythms of conversation and movement (MacIvor, 1999).

Teaching through Modeling and Demonstration. Reflective learning style is closely tied to the visual learning patterns of American Indian children (Tharp, 1994). Numerous findings support the view that American Indian/Alaska Native students are visual learners. Visual learners seem to learn best when they are able to see the material, procedure, and processes they are expected to master. Their learning seems to improve best when the teacher provides a myriad of visual learning opportunities such as graphs, films, demonstrations, and pictures. The source of this strength may be a reflection of the traditional life styles of Indian cultures. As mentioned before, when skills were taught at home, parents or elders generally taught through demonstration and modeling. Although traditional, the importance of the visual sense may continue to be a part of teaching styles and, thus, learning styles. In fact, according to research, many American Indian/Alaska Native students appear to perform best in classrooms with an emphasis on visualization, especially in mathematics (Tharp, 1994).

The term *visual learner* is expanded by some authors to the more global term *imaginal learner* (e.g., More, 1993; and Riding & Rayner, 1998). The more imaginal student learns better from images, symbols and diagrams. The more imaginal student remembers

better if the coding uses images to regulate behavior. On the other side, the more verbal learner learns better from highly verbal explanations or from dictionary-style definitions, relies more on words and labels, uses verbal regulation of behavior more effectively, and codes concepts verbally.

The Center for Research on Education Diversity and Excellence (CREDE) proposes that, when teaching mathematics to American Indian students, teachers "include some performance and demonstration" (Tharp, Dalton, & Yamauchi, 1994 in Hilberg et al., 2002). The inclusion of models or demonstrations in lessons increases students' understanding of explanations. But visual modeling, while highly recommended, is not the only means for demonstration. Effective instructional conversations can include modeling (Hilberg et al., 2002). The use of imagery as a way of communicating complex or abstract concepts has always been an important part of learning in most Native Indian cultures (More, 1993). Legend systems and stories are excellent examples of such usage. This approach to communication could be behind the result that Native Indian students are more likely to have an imaginal than a verbal learning style.

Lipka and his team (2005) point out that modeling needs to go beyond mere repetitive and craft-making tasks. The teacher should include the modeling of "visible and explicit thinking strategies that experts use in particular domains" (Lee, 1995 in Lipka et al., 2005). Also, the teachers should coordinate their verbal behavior and their physical modeling. Again, in the words of former Yup'ik teacher Evelyn Yanez:

> you have to show it instead of just talking about … verbally and kinesthetically, that is how I was raised…My dad always says that a person could be very verbally telling people how to do things but if he can't show then he may not know (E. Yanez in Lipka et al., 2005, p.49).

A number of research studies have provided data which support the theory that American Indian children tend toward reflective and visual learning styles. Lipka and his team (2005) refer to modeling as *expert-apprentice modeling* and see it as a culturally responsive way to bridge the explicit teaching of concepts and the independent application of complex skills by learners. One of their modules from *Math in a Cultural Context* (MCC) is called *Patterns and Parkas: Investigating Geometric Principles, Estimation, Angles, Patterns, and Area* (Pendergrast et al., 2006). It is a second-grade module about geometrical relationships with emphasis on the square. It includes the traditional Yup'ik process of making pattern pieces through folding along lines of symmetry and applying them to clothing, in particular to the Yup'ik women's fur parkas (for more on this module check Lipka et al., 2006; and Pendegrast et al., 2006). In the case study of Ms. Sharp (Lipka et al., 2005), we can see how the Yup'ik teacher uses modeling, joint activity, and culturally relevant pattern creation. During a class with kindergarten and first graders, Ms. Sharp asks students to make a square out of black construction paper. She sometimes uses her hands to draw a square in the air but her students are not quite following. The students (and the teacher) are sitting on the floor and soon start playing and turning the paper into hats. Ms. Sharp then takes a piece of construction paper and begins modeling the process and coordinating her modeling with her verbal instructions. In seconds, students remove their "hats," move closer to observe her, and start making their own squares. Soon after she starts modeling, they are all observing and on task. This is an example of the proper use of modeling for teaching mathematics to American Indian/Alaskan Native students. When Ms.

Sharp coordinated her verbal behavior and her physical modeling, students were eager to get involved (Lipka et al., 2005).

Several investigators (Longstreet, 1978; John, 1972; Leighton & Kluckhohn, 1948) have reported that Navajo children repeatedly observe an activity and review the performance in their heads until they are certain that they can do the task well the very first time they undertake its performance. Similar observations were reported by Brewer (1971) when describing learning by Oglala Sioux children at home and school. Brewer says that children used processes of observation and self-testing in private, followed by demonstration of a task for approval as essential steps in their acquisition of knowledge and skills. "Learning through public mistakes was not and is not a method of learning which Indians value" (Brewer, 1971, p. 22 as cited in Swisher, 1990). This process relates closely with the need for modeling and reflective observation mentioned in the previous section.

Wax, Wax, and Dumont (1964) gave examples of learning in Oglala Sioux society, where individuals must observe tasks in actual practice before attempting performance. Brewer (1977) also suggested that observation, self-testing in private, and then demonstration of a task for approval were essential steps in learning. Making mistakes in public was not, however, accepted as a way to learn.

Similar evidence regarding observation as a prerequisite to performance was presented about Navajo (Werner & Begishe, 1968; Longstreet, 1978) and Yaqui societies (Appleton, 1983). These cultures respect the ability of a person to learn experientially, without the constant supervision and correction so characteristic of formal instruction. This respect gives individuals the autonomy of knowing when performance of a task is ready for

public scrutiny. Such studies show that the way in which children demonstrate their learning in a school setting is related to the way they have acquired knowledge.

Philips' study (1983) provides a general model for looking at how children from Native groups interact in the classroom. He observed classrooms attended by Indian children in Warm Springs, Oregon. Philips described a process of acquiring competence that reflected Warm Springs' norms: observation, careful listening, supervised participation, and individualized self-correction or testing. The norms of their culture helped explain why the children were reluctant to speak in front of their classmates. Similar disruption of cultural patterns in classrooms attended by Sioux and Cherokee children had been reported previously by Dumont (1972).

In another study, the Myers-Briggs Type Indicator was used to examine the learning styles of American Indian and African American secondary students (Nuby & Oxford, 1998), revealing significant differences: students in the African American sample scored higher on the "judging" scale, associated with quick decision making, while students in the American Indian sample scored higher on "perceiving," associated with a more relaxed, reflective, decision-making style.

Deyhle and Deyhle (1987, in Wilcox, 1996) found in their study regarding learning styles of American Indian and Alaskan youth that these students have a common pattern in the way they come to know or understand the world. The American Indian students approach tasks visually, seem to prefer to learn by careful observation that precedes performance, and seem to learn best experientially, with many opportunities to experience quiet, persistent explorations.

Rougas (2000) used the Woodcock-Johnson Psycho-Educational Battery Test of Cognitive Ability to examine differences between Mohawk and white adolescents' visual abilities. Her study found significant differences, with students in the Mohawk sample demonstrating greater strength in visual processing.

Morton, Allen, and Williams (1994) used the Wechsler Intelligence Scale for Children to test differences in language and non-language tasks with English monolingual Ojibwa and non-Indian adolescents. They found that students in the American Indian sample performed better on subtests linked with visual/spatial processing, and that the control group did better on language subtests.

Thus, studies are fairly consistent in supporting the view that American Indians are reflective learners as well as high in spatial and visual abilities. Barta (1999), for example, talks about the benefits of using beadwork in the mathematics classroom. Beadwork, he claims, provides a hands-on demonstration of mathematics in action and can be used as an effective vehicle for teaching mathematics. There is virtually no mathematical concept (appropriate for elementary students) that cannot be illustrated using beadwork (Barta, 1999).

Summary of Findings. The teachers' use of modeling to prepare students to learn a new skill, process, or procedure or to reinforce a previously introduced one has proven to be effective in American Indian students' learning of mathematics. We have to be aware though that modeling must not be relegated to repetitive and craft-making tasks. For modeling to be effective with American Indian students, the teacher should coordinate verbal

and physical modeling to make visible and explicit thinking strategies that experts use in particular domains.

Mathematics Teachers' Beliefs, Review of Studies and Their Methodologies

There is general agreement in education research that teaching is a cognitive activity and that the beliefs that teachers hold about mathematics, teaching, and learning greatly impact their instructional decisions in the classroom (Calderhead, 1996; Pajares, 1992; Thompson, 1992; Tillema, 2000; Shavelson & Stern, 1981; Speer 2001). Obviously teacher knowledge, goals, and teaching contexts influence what happens in the classroom, but the research of those factors alone without consideration of teachers' beliefs will not be sufficient to understand why teachers do what they do. In fact, Pajares (1992) says that what teachers view as appropriate practice and the knowledge they see as relevant are influenced by their beliefs in significant ways. Extensive research has been done in the field of teachers' beliefs with different approaches and purposes. In the following pages a review of the different methodologies used in the field will be presented.

Despite the remarkable attention that educational research has devoted to teachers' beliefs in the last decades, there has been relatively little inquiry into the nature of assumptions underlying dominant methodological approaches (Speer, 2005). This section of this dissertation is intended to contribute to this inquiry by reviewing the methodologies used in the research of mathematics teachers' beliefs and discussing the strengths and limitations of those methods. Since theories, findings, and methods are inextricably intertwined (Schoenfeld, 1992), we must examine theory findings and methods collectively.

First, I provide a brief survey of the existing research on mathematics teachers' beliefs. The later sections are devoted to a description and analysis of the methodologies that have been typically used in this research.

Beliefs and Teachers' Beliefs (History)

During the first two decades of the 20th century, some social psychologists were interested in the study of beliefs and their influence on behavior. With the emergence of associationism in the 1930s and the difficulty of accessing beliefs, the interest decreased and practically disappeared. The 1960s brought a renewed interest in the study of beliefs. The growth of cognitive science in the 1970s opened the doors to the study of belief systems in relation to other aspects of human cognition (Thompson, 1992). It was not until the 1980s that the interest in beliefs resurged and spread among researchers from very diverse disciplines including education.

Research on teachers' beliefs has changed over the past decades mirroring the changes in paradigms for research on teaching (Thompson, 1992). In the late 1960s and the beginning of the 1970s the research on teachers and teaching was strongly influenced by the behaviorist tradition whose aim was to describe teaching in terms of behavior sequences and to investigate how those sequences related to children learning (Calderhead, 1996). Later in the decade, the focus shifted to teachers' thinking and the processes of decision-making. In the following decades, educational research on beliefs examined more extensively the role of cognition and contexts of learning. The studies not only looked at teachers' behaviors but also addressed teachers' perceptions, thinking, judgments, reflections, evaluations and routines (Speer, 2001).

Regarding mathematics education, only a few studies specifically addressed the beliefs of mathematics teachers before the 1980s. Since 1980, however, many studies in mathematics education have focused on teachers' beliefs about mathematics and mathematics teaching and learning. Most researchers since 1980 operate on the assumption that understanding the beliefs with which teachers define their work is necessary for understanding teaching from teachers' perspectives (Nespor, 1987; Thompson, 1992).

Definitions of Beliefs

Despite the prevalence of research on teachers' beliefs in the educational literature, there is considerable debate about the definition of what "belief" means and how beliefs can be categorized. Some researchers have recognized the difficulty of finding a precise definition and have described beliefs as a "messy construct" with different meanings and interpretations (Pajares, 1992). Others have attempted more concrete definitions. For example, in Ernest (1989) we find beliefs defined as a person's conceptions, personal ideologies, world views, and values (Aguirre & Speer, 2000; Ernest, 1989).

In the mathematics education literature, current definitions of beliefs focus primarily on how teachers think about the nature of mathematics, teaching, learning, and students. In this context, beliefs are defined as conceptions, personal ideologies, world views, and values that shape practice and orient knowledge (Ernest, 1989; Pajares, 1992; Thompson, 1984, 1985, and 1992).

Only a few researchers state clearly their definitions of beliefs when reporting their studies. In her study of calculus teaching assistants' beliefs and practices, for example, Speer

(2001) states that a teacher "has a particular belief" when that teacher was "behaving in a manner that is consistent with having that belief."

One of the complexities in defining beliefs is distinguishing between beliefs and knowledge. The problem increases when researching teachers' beliefs. It is not uncommon in education for alternative, even contradictory, theories to coexist (Thompson, 1992). This may help explain the difficulty of separating teachers' knowledge from beliefs. Also, researchers have noticed that teachers often treat their beliefs as knowledge. This phenomenon has motivated some researchers who investigate teachers' knowledge to also consider teachers' beliefs (Grossman, Wilson, & Shulman, 1989 in Thompson, 1992; Speers, 2001).

Different approaches have been used to distinguish beliefs from knowledge based on the particular characteristics of each (Calderhead, 1996; Nespor, 1987; Thompson, 1992). The affective nature of beliefs has been used to distinguish them from knowledge (Nespor, 1987; Pajares, 1992; Speers, 2001). Another characteristic used to differentiate beliefs from knowledge is that only beliefs can be held with varying degrees of conviction (Thompson, 1992). A distinctive feature of beliefs is that they are not consensual; the believer is aware that others may think differently (Abelson, 1979 in Thompson, 1992). Truth or certainty is associated with knowledge while beliefs are held independently of their validity. Another characteristic of knowledge is the existence of a general agreement about the procedures for evaluating and judging its validity. While knowledge must meet criteria involving canons of evidence, beliefs do not and are often held for reasons that do not meet those criteria (Thompson, 1992). Thompson (1992) points out, however, an important caveat: as old

theories are replaced by new ones, the evidence against which a claim to knowing is evaluated may change. As new theories develop, what may have been rightfully claimed as knowledge at one time may be judged as belief. Conversely, a once-held belief may be later considered knowledge in light of new supporting theories.

Categories and Beliefs Systems

In studying beliefs, researchers have also proposed organizational schemes to capture beliefs and the relationships among them. These organizational schemes, typically referred to as "belief systems" (Green, 1971), range from simple sorted lists based on categories to more complex hierarchies. Researchers have also proposed different theoretical frameworks and rationales for the existence and structure of belief systems. Green (1971) described several ways of viewing and organizing beliefs. Green claimed, for example, that a set of beliefs could be organized based on how strongly they are held by a person.

Researchers have often delineated categories of beliefs (e.g. Ernest, 1985, 1988, 1989; Lerman, 1990; Prawat, 1992). One common approach is to sort beliefs based on what they are about. The most common example in education is to categorize beliefs about subject matter (in this case, mathematics), teaching, learning, and students. These categories can also be subdivided. For example, mathematics can be subdivided into algebra, calculus, etc. and learning can be subdivided into problem solving, computational skills, etc. Regarding beliefs about mathematics, some researchers have borrowed categorization schemes from the philosophy of mathematics. Other categorizations are based on different views of the nature of mathematical knowledge. Beliefs about teaching and learning have also been categorized.

Teachers' Beliefs and Practices

One of the most important contributions of research on teachers' beliefs is that the beliefs that teachers hold about mathematics, teaching and learning influence (even shape) their teaching practice (Calderhead, 1996; Pajares, 1992; Thompson, 1992). Obviously teacher knowledge, goals, and teaching contexts influence what happens in the classroom, but the research of those factors alone without consideration of teachers' beliefs will not be sufficient to understand why teachers do what they do. In fact, Pajares (1992) says that what teachers view as appropriate practice and the knowledge they see as relevant are influenced by their beliefs in significant ways.

While there is a general agreement regarding the fact that teachers' beliefs influence their practice, there is also a general concern about the complexity of the issue. When studying how teachers' beliefs affect their practices, researchers have found a strong but not a simple cause-effect relationship. Instead, they suggest a complex relationship and recommend further study (Thompson, 1992; Benken, 2004). With these results and concerns in mind, researchers have examined the extent to which teachers' stated beliefs about mathematics, teaching, and learning are reflected or not in their instructional practice. In some cases, researchers found that teachers' beliefs were consistent with what was reflected in observations of their classroom practices. Thompson (1985), in her study on teachers' conceptions of mathematics and the teaching of problem solving, described a seventh grade teacher named Kay who taught mathematics to *gifted* students. According to Thompson, Kay viewed mathematics as a "subject of ideas and mental processes rather than a subject of facts." She also viewed the study of mathematics as "discovery and verification of ideas."

Kay's beliefs were said to be consistent with Thompson's observations which noted that Kay "frequently encouraged the students, in a rather persuasive tone, to guess, conjecture, and reason on their own, explaining to them the importance of these processes in the acquisition of mathematical knowledge" (p. 289). Thompson, therefore, noted great consistencies between Kay's stated beliefs and her observations of Kay's teaching. However, inconsistencies between beliefs and practices have also been documented. Thompson (1984), for example, in her study of the relationship of teachers' conceptions of mathematics and mathematics teaching to instructional practice, described a teacher named Lynn who believed mathematics instruction should encourage students to ask questions and participate actively in discussions. Thompson observed that Lynn's practice consisted primarily of lectures followed by routine sitwork. These practices, strongly restricted student participation and the opportunity to ask questions which contradicted Lynn's stated beliefs. Researchers have presented many possible explanations for perceived inconsistencies between beliefs and practice (e.g. Ernest, 1989; Speer, 2001; Thompson, 1992; Wilson & Cooney, 2002). The explanation might be found, for example, in the structure of beliefs and the relative force that other beliefs might have over the one in question (Speer, 2001).

Alternatively, the inconsistencies reported in some studies might be a reflection of the complexity of the relationship between teachers' beliefs about teaching and learning and their instructional practice. The relationship, though, does not seem to be a simple cause-and-effect one (Thompson, 1992). Ernest's (1989) proposed causes all appeal to characteristics of teachers and contexts while Wilson and Cooney (2002) suggest that the answer may lie in the "practical or logistical circumstances" of teaching that prevent teachers

from acting in accordance with their beliefs. The influence of social contextual factors is documented by Brown (1985) and Cooney (1985) in their study of a teacher named Fred (Table 1), a novice secondary teacher. In her study of Fred's "socialization to teaching," Brown documented discrepancies between Fred's beliefs and practice. Cooney describes the tensions and conflicts that Fred experienced between his strong views about mathematics teaching (in particular, the importance of problem solving) and his perceptions of the realities of his teaching situation which he claimed imposed numerous obstacles to implementing his views. Pressure to cover subject matter and maintenance of class control forced Fred to compromise his beliefs about problem solving as an instructional goal. The structure of beliefs and the relative force that other beliefs might have over the one in question has been pointed out by some researchers as yet another possible explanation for those inconsistencies (Thompson, 1992).

Even though none of the explanations presented above pointed to methods of research and their potential influence on findings, the inconsistencies between beliefs and practice generated a dialogue about the methodology used for research on beliefs. Many suggested that reported inconsistencies between beliefs and practice could be explained in part by the way teachers' beliefs have been measured. Reliance on verbal data and possible researchers' misinterpretation of what teachers mean when talking about their beliefs are among the potential methodological explanations that will be discussed later in this chapter.

Table 1. Cooney (1985) and Brown (1985)

Cooney (1985) and Brown (1985) studied a beginning secondary mathematics teacher named Fred to determine the elements involved in his socialization to teaching. The specific questions that guided Brown's study related to the influences of different factors on the actions and thoughts of the teacher in the classroom. Cooney, particularly, focused his study on Fred's beliefs about problem solving.

Fred was studied over a period of approximately one and one half years. Data collection began as the teacher was a pre-service master's degree student and continued to the end of his first year of teaching. Interviews in which he responded to various types of open-ended situations, his reaction to a report written about his beliefs, participant observation in the school, artifacts, and questionnaires were used as data sources to reveal Fred's beliefs.

The data suggest that the way Fred thought about his role in the classroom and performed that role during his first of teaching was most significantly influenced by his university teacher education program, and by his perceptions of his students' conceptions of mathematics teaching and their maturity and ability levels. Central to the conception of mathematics teaching with which Fred entered his first year of teaching was a belief that problem solving was the essence of mathematics and that interesting mathematical problems could motivate students to learn mathematics. Analysis revealed conflicts between his idealism and reality of his classroom situation.

Teachers' Beliefs, Preparation and Change

In studies about teachers' preparation and change, researchers have noted that the beliefs that prospective teachers bring to their preparation programs appear to play a significant role in how teaching practices develop and evolve (Ball, 1988; Borko & Putnam, 1996; Richardson, 1996). Researchers studying the origins of pre-service teachers' beliefs about mathematics learning and teaching have noted that most of those beliefs are formed during their schooling years, from their experiences as students and their "observations" of teachers (Ball, 1988; Thompson, 1992). Existing beliefs (and knowledge) shape how new information and experiences are understood and how new knowledge develops (Borko, 1996; Speer, 2001). Teachers' preparation programs have to acknowledge these prior beliefs

and experiences in order to succeed. Similar results emerge from the research on teachers participating in professional development programs and the research on the impact of new reforms or standards in schools. When experienced teachers attempt to learn to teach in new ways, they are highly influenced by what they already know and believe about teaching, learning, and learners. Similarly, the beliefs that teachers hold greatly influence their implementation of reform-oriented practices in their classrooms (Borko, 1996; Speer, 2001).

Methodologies Used in the Studying of Teachers' Beliefs

Background

Before discussing the methodology used in the study of mathematics teachers' beliefs, a general overview of the literature will be helpful to gain a sense of the range of the research and of the diversity of purpose, design, and technique that can be found across studies. For extended reviews of the literature on mathematics teachers' beliefs, see Calderhead (1996), Tompson (1992), or Pajares (1992).

Studies on mathematics teachers' beliefs are very diverse in focus, purpose, sample target, design, and methodology. When studying mathematics teachers' beliefs, researchers have focused on teachers' beliefs about mathematics, mathematics teaching, mathematics learning, or combinations of the three. While some researchers focused on pre-service teachers (Evans, 2003; Harrington, 2000; Helms, 1989; Owens, 1987), others looked at in-service teachers (Alba, 2001; Benken, 2004; Chow, 2001; Grant, 1984; Pittman, 2002; Speer, 2001). Sometimes the subjects in the study are experienced teachers (Pittman, 2002) and sometimes they are novices (Brown, 1985; Benken, 2004; Speer, 2001). Participants in the studies about teachers' beliefs vary from elementary to secondary, from junior to senior

high teachers. Seldom does research on teachers' beliefs involve a mix of pre- and in-service teachers or a mix of elementary and secondary teachers.

Describing the substance of teachers' beliefs has been the purpose of some studies (Chow, 2001; Grant, 1984; Helms, 1989; Owen, 1987; Thompson, 1985), while others have tried to delineate categories of beliefs. Many studies have examined the relationship between teachers' beliefs and classroom practice (Benken, 2004; Grant, 1984; Pittman, 2002; Speer, 2001; Thompson, 1984). The purpose of yet another set of studies has been to examine the process of changing teachers' beliefs (Brown, 1985; Evans, 2003; Harrington, 2000). Some researchers have compared teachers' beliefs with new standards, new reforms, etc. (Alba, 2001; Floyd, 2006).

The variability in the purpose of the research reflects on the diversity of research designs that can be found in the literature. The span goes from ethnographic case studies of one or few teachers (Alba, 2001; Brown, 1985; Helms, 1989; Owens, 1987; Speer, 2001; Thompson, 1984) to standardized administration of belief inventories (Evans, 2003; Floyd, 2006). Although due to the conceptual nature of the topic, most of the studies in beliefs have employed qualitative methods of analysis (Alba, 2001; Brown, 1985; Speer, 2001), while some quantitative studies (Evans, 2003; Floyd, 2006) can be found in the literature (Evans, 2003; Floyd, 2006). Many different techniques have been used to obtain data on teachers' beliefs and practice. The different methodologies that have typically been used will be discussed in the following section.

This section is divided into three parts describing the most common methods used to: (1) investigate teachers' beliefs; (2) examine classroom practices; and (3) relate the two.

In the last section, the methodology will be discussed, concerns will be addressed and some possible new approaches will be presented.

Tools Used to Study Teachers' Beliefs. When analyzing the substance of teachers' beliefs in mathematics and mathematics teaching and learning, many different tools have been used. The methods used range from large-scale surveys (Evans, 2003; Floyd, 2006) to in-depth case studies (Alba, 2001; Brown, 1985; Helms, 1989; Owens, 1987; Speer, 2001). Much of the work on beliefs is based on teachers' self-reports obtained through various channels including interviews, questionnaires (especially Linkert-scale type), linguistic analysis of teachers' talk, paragraph completion tests, and concept generation and mapping exercises such as the Kelly Repertory Technique (Owens, 1987). In some cases, simulation materials such as written or videotaped vignettes describing hypothetical students or classroom situations are used as prompts. In most cases, instead of being derived from the practices of the teachers involved in the study, these simulation materials are pre-designed by the researcher (Leder & Forgasz, 2002). Rather than a single technique, most studies have employed a combination of techniques. Through interviews, questionnaires, and other self-reported methods, researchers build descriptions of beliefs expressed by teachers. Once the belief data are gathered, beliefs are often categorized. Sometimes the categories are derived empirically from the data and other times predefined categorization schemes are used (Table 2). In most cases, the rationale behind those categorizations is not explained in great detail.

Table 2. Evans (2003)

Evans' (2003) study involved an investigation of early childhood (K–5) pre-service teachers' beliefs about the nature of mathematics, how mathematics should be taught, and how mathematics is learned. The purpose of the study was to determine the beliefs of groups of early childhood (K–5) pre-service teachers who were at different points of completion of a sequence of four mathematics content courses required for the Early Childhood Teacher Education Program, and to determine if any differences in beliefs existed among the groups. Overall, the results indicated that the pre-service teachers conceived of mathematics as facts, rules, and procedures to be memorized, teaching as presenting rules and procedures to students, and learning mathematics as simply acquiring procedural knowledge/understanding.

Among other data collection tools, Evans (2003) used several Linkert-Scale type beliefs instruments in which the items that define the beliefs categories were based on the Standards designed by the National Council of Mathematics (NCTM, 1989; 2000). For example:

Item (p. 255)	Basis in Standards (NCTM, 2000)
Students should share their problem-solving thinking and approaches WITH OTHER STUDENTS.	Instructional programs from prekindergarten through grade 12 should enable all students to communicate their mathematical thinking coherently and clearly to peers, teachers, and others (p. 59)

Some researchers contend that teachers' verbal data alone is not sufficient for an accurate portrayal of their beliefs. They suggest that investigation of mathematics teachers' beliefs should examine data from observations of instructional practice along with the verbal data (Thompson, 1992). Even though the protocols used to derive beliefs from observed practices is usually not specified in much detail, observation of classroom practice has become a common tool in the research on mathematics teachers' beliefs. Characterizations of particular beliefs are usually derived from behaviors observed that are considered "consistent" with holding that belief. The definitions of the descriptive terms presented in

the studies are rarely specified in detail. It is assumed in most cases that teachers, researchers, and readers have the same understanding for the meaning of the terms used.

Instructional Practice. Data on instructional practice typically comes from three sources: classroom observations, teachers' self-reports, and the analysis of classroom artifacts such as student assignments or lesson plans (e.g. Benken, 2004; Harrington, 2000). Observations are documented in writing, audio-recorded, or videotaped. Written data gathering methods include field notes or more structured systems for recording observations.

Data about instructional practice is sometime collected in ways other than classroom observations. Sometimes teachers are asked to describe what their classes are like and sometimes teachers are asked about their use of specific teaching practices. On other occasions, teachers' instructional practices are inferred from analyzing classroom artifacts such as student assignments and other teaching materials (Table 3). Again, little detail is given about how the data gathered in these ways are analyzed and the definitions of descriptive terms are rarely shared.

Relations between Beliefs and Instructional Practice. Regardless of which methods are used, when data are collected for both teachers' beliefs and instructional practice, the researchers typically examine the relationships between teachers' beliefs and their practices. Researchers usually look for correlations (Table 4) among beliefs and observed or reported practices. How these analyses are conducted is often described only in very general terms.

Table 3. Brown (1985)

This an excerpt from Brown (1985) in which she explains the use of artifacts in her study of Fred (see p. 6 for a description of the study):

Artifact gathering: In addition to field notes taking during participant observation, I collected various artifacts from Fred's classroom, the school, and the community to be used as data.

Such artifacts provide evidence for the topics and questions ethnographers [researchers] address because they are material manifestations of the beliefs and behaviors that constitute a culture. (Goetz & LeCompte, 1984, p. 153)

Artifacts such as sample tests and homework assignments, daily attendance and school announcement memos, and school and community newspapers were used to help complete the picture of Fred's experience. A representative sample of these items was collected throughout the period I was in the school. (Brown, 1985, p. 26)

Table 4. Thompson (1995)

The correlations among beliefs and observed or reported practices are not statistical.

Remember, for example, Thompson's study (1995) of Kay's beliefs (*see page 5 for description)*. From observing that Kay

> *"frequently encouraged the students, in a rather persuasive tone, to guess, conjecture, and reason on their own, explaining to them the importance of these processes in the acquisition of mathematical knowledge",*

Thompson interpreted that type of behavior was consistent with Kay's views of mathematics as a "subject of ideas and mental processes rather than a subject of facts". She also viewed the study of mathematics as "discovery and verification of ideas."

Discussion: Concerns, Recommendations and New Approaches

In this section, the methodology described before will be discussed, concerns will be addressed, and a new approach emerging in the research community will be presented.

Methodology and Concerns

As mentioned before, researchers have examined the extent to which teachers' stated beliefs about mathematics, teaching, and learning are reflected in their instructional practices. A review of the research devoted to investigate the issue showed that both consistencies and inconsistencies have been found. I have already presented some of the causes not related to methodology that researchers have used to explain inconsistencies. However, these discrepancies have also brought a dialogue in the educational research community about the validity of the methodologies used for this type of research.

Attributing Beliefs from Verbal Data. Reported inconsistencies between professed beliefs and observed practice, like those noted in the studies of Lynn and Fred, could be explained in part by the way teachers' beliefs have been measured. Reliance on verbal responses to questions posed at an abstract level of thought as the only source of data may be problematic. Some of the beliefs stated by teachers could be, for example, "more a manifestation of verbal commitment to abstract ideas about teaching and learning than an operative theory of instruction" (Thompson, 1992). This might be accountable for some of the inconsistencies (Shaw, 1989). Novice teachers, like Fred, may be particularly sensitive to this since they have not had many occasions to contrast those abstract ideas with practice and modify their views accordingly. Teachers may sometimes manifest their teaching ideals while knowing that those ideals cannot be realized perhaps due to the lack of knowledge, skills, or circumstance to implement them. Ball (1988), for example, reported that some pre-service teachers recognized how, in order to teach conceptually, they needed a broader, deeper understanding of the mathematics involved. If inquired about his/her beliefs about

it, a novice teacher might say that he/she firmly believes in teaching conceptually. A researcher observing his/her classroom might think otherwise.

Attributing Beliefs from Classroom Observations. With the potential limitations of the use of verbal data alone in mind, researchers have found it informative to examine both the beliefs that teachers state and those inferred from observation. This has led to separate classifications of what teachers say (professed beliefs) and what is reflected in their practice or inferred from other data (attributed beliefs) (Calderhead, 1996; Thompson, 1984).

Misinterpretations and Lack of Shared Understanding. The distinction between professed and attributed beliefs has become a fixture of the research on teachers' beliefs and practices and has influenced the research designs and methods used. It is possible that a cause for reported inconsistencies between professed beliefs and practice is the discrepancy between what teachers say and the researcher's interpretation of what they are saying. Those perceived discrepancies could sometimes be the result of incomplete or inaccurate understanding of terms and descriptions used by teachers and researchers. Wilson and Cooney (2002) suggest that discrepancies may appear when researchers "do not have a viable interpretation of what the teacher means" when using specific terminology.

Speer (2005) builds on Wilson and Cooney's (2002) work and claims that perceived discrepancies are sometimes the result of incomplete or inaccurate understanding of terms and descriptions used by teachers and researchers. Later, when discussing Speer's model, I will give an example of this situation. The researcher's job of attributing beliefs to teachers is complicated by the possibility of researchers and teachers meaning different things when

using the same terms. As mentioned before, questionnaires and interviews are primary sources for information about teachers' beliefs. On questionnaires or in interviews, terms used by researchers to describe beliefs and practices (for example, problem solving) may not mean the same thing for the teachers and the researchers involved in a study. Speer (2001, 2005) refers to this disconnect between teachers and researchers as lack of *shared understanding*. This disconnect could potentially lead to data that may not accurately represent teachers' beliefs or practices and may shape findings and conclusions in significant ways. One approach to minimize the lack of shared understanding could be, for example, for both the researcher and participant to have an initial discussion to share their vocabulary and understanding of various descriptive terms and then agree to a particular meaning for the terms. While this approach might be useful in some circumstances, Speer (2005) points out that one should be cautious; some teachers might feel that the researcher's definition of a term is "correct" given the researcher's presumed authority on education. The teacher might then agree to use the researcher's definition even if it is not the definition the participant has in mind.

The problem of not sharing the same understanding of terms might occur when researchers make attributions of teachers' beliefs based on observations of practice. What happens in the classroom may fit the teachers' conception of, for example, problem solving, but the researcher may hold a very different definition of what problem solving is. Therefore, if the researcher observes the teacher and does not see anything reflecting a belief in the importance of problem solving, the researcher will conclude that there is an inconsistency between what the teacher claims to believe and what he/she must really believe. Some

researchers have gone back to the teachers after observing them teach and have shared with them their conclusions to see if their attributions accurately reflected what the teachers really believed. Cooney (1985) went back to Fred after a series of interviews during his pre-service education and asked him for input on the written report about his beliefs. Researchers must keep in mind that concluding what a teacher does in the classroom does not reflect the researcher's conception of particular terms (e.g., problem solving) and is not the same as saying that the teachers' beliefs and practices are inconsistent. Unfortunately, methods typically used do not help to distinguish between situations where there really are discrepancies between what teachers believe and how they teach and those where discrepancies are between researchers' and teachers' definitions of descriptive terms (Speer, 2005). To address these issues, the design of research should acknowledge the possibilities of people meaning different things for the same concept. Methods should provide researchers with access to teachers' definitions of the terms they use to describe their beliefs and practices. Since work on beliefs is highly dependent on descriptions and terms used by researchers, methods should be designed to help teachers and researchers agree on the terms and definitions used for the study. The presence of shared understanding needs to be checked more than once during the data collection process. If the researchers realize that they are using terms in different ways, methods need to enable the researcher to have access to the teachers' meaning for the terms. In the case of Cooney's study of Fred, for example, after the initial series of interviews the researcher and his assistant observed and interviewed Fred several times more during his first year of teaching. Even though the belief report was shared with Fred after the initial interviews, there is no evidence in the report of the researcher

sharing the conclusions derived from these later observations and interviews. It might have been beneficial for the study if the researchers had shared the final analysis and conclusions with Fred to assess whether the results seemed accurate to him.

The Context of Beliefs. As mentioned before, in much of the research that examines connections between beliefs and practices, data on beliefs and on practices are collected and categorized separately and then compared. But if a teacher's beliefs are situated in particular contexts as some researchers have maintained (e.g. Ernest, 1989; Hoyles, 1992, Speer, 2005; Thompson, 1992; Wilson & Cooney, 2002), then teachers may or may not exhibit consistency in their beliefs from one context to another. It would make sense then that data on beliefs would come from sources that are tied to the particular practices that one seeks to understand. Speer (2001, 2005) suggests that instead of beginning with data collection about beliefs and then analyzing data on practices in light of the findings about beliefs, one can begin with practices and gather data related to beliefs in connection with those practices and contexts. One approach, she suggested, could be for the researcher to observe the teacher in the classroom before the interview to gather some data related to beliefs in connection to those practice. Then the researcher could interview the teacher using some of the observations as prompts for the interview. This might also help to avoid researchers' misconceptions related to teachers' beliefs based on the observations suggested earlier with Cooney's study of Fred.

Categorizations. When attributing beliefs to teachers from practice or even when interpreting teachers' own statements about their beliefs, researchers have to try to be as

accurate as possible. Obviously, researchers shape how data is portrayed and even teachers' self-reported data is framed by the design of the study and its methodology. Some times, for example, researchers use previous categorization schemes for beliefs. Evans' study (2003) is a good example of that (see sidebar on p. 11). Could this use of previous categorization schemes for beliefs unintentionally influence the findings of the study? If methods can only capture beliefs that fit into particular categories, researchers might be unintentionally blinding themselves to other possibilities. This is an inherent characteristic of qualitative research not unique to studies of teachers and teaching. This is, in fact, the reasoning that lies under the distinction between attributed and professed beliefs. Researchers need to be aware of these issues and seek out methods that allow for the most accurate attributions possible.

An Alternative

Based in part on other researchers' use of "videoclubs" as a professional development activity and as a source of data on teacher cognition (Frederiksen et al., 1998; Nathan et al., 1998; Sherin, 1996, 2002), Speer (2001) designed a method called *videoclip interviews* that address most of the concerns I have mentioned above. Videoclip interviews seek to achieve a better shared understanding for researchers and teachers to improve the accuracy of teachers' beliefs attributions, and to facilitate data collection that focus on the context of the study. A brief description of the method will follow as well as some evidence and discussion of its validity. For a more detailed description of this method and rationale for its use, see Speer (2001).

Description of Speer's Videoclip Methodology

Prior to any discussion with the teacher involved in the study, the teacher is videotaped while teaching. Then the researcher views the videotape and, before each interview, selects excerpts from the video to discuss with the teacher. After excerpts have been selected, the researcher uses them as prompts during the interview. The teacher is asked to explain what she or he was doing during the excerpt and why. The interviews do not follow a rigid script, allowing the flexibility to pursue issues raised by teachers as they discuss each videoclip. This discussion is used to build shared understanding by allowing vocabulary to emerge and by providing a meaningful context for the discussions. Participants have the opportunity during the interviews to share their meanings of particular descriptive terms and to connect them with examples from their practice as captured on the videotape. If the participant's definition does not match the researcher's, then the researcher can (for the purposes of the interview and data analysis) adopt the participant's definition of that term. Then the researcher can use descriptive terminology and be relatively certain that terms mean the same thing to the participant.

Evidence Supporting the Use of Videoclip Interviews

Speer (2001) examined how the beliefs of two graduate teaching assistants, Zachary and Karl (Table 5), were connected to their teaching practices in calculus courses. In the case of Zachary and Karl, the analysis of interview data and later observations independent of videoclips revealed discrepancies between beliefs and practices. Speer went back to both of them with videoclips of their practice using those as prompts for the interviews. When data from videoclip interviews were used, analyses of that data revealed what Karl and Zachary

really meant by the terms they used, and the perceived inconsistencies between their professed and attributed beliefs were resolved. The shared meanings that emerged from the use of videoclip interviews enabled a richer understanding of their beliefs and teaching practices to emerge.

Potential Benefits and Concerns

I have chosen to present videoclip interviews as a model methodology in this chapter because I think this technique tries to address all of the concerns about methodology in research on teachers' beliefs that I have identified in this chapter. By using videoclips of teachers' classes in interviews, it is possible to obtain information beyond what is possible in traditional, de-contextualized interviews or in a combination of interviews and observations. When asked to describe a videoclip, teachers provide the researcher with descriptive terms that have meaning for them, thereby making it possible for researchers and teachers to generate shared understanding of terms. This method also addresses two other issues: (1) videoclip interview methods enable researchers to collect data on beliefs tied to specific examples of teachers' practices; and (2) data is generated that permits more accurate attributions of beliefs. The use of videoclips can help to build shared understanding by allowing vocabulary to emerge during the interviews and by providing a meaningful context for the discussions. Instead of discussing beliefs and teaching practices in the abstract, videoclips provide concrete contexts around which discussions can be focused.

Table 5. Speer (2005)

*These are some excerpts from **Speer (2005)** explaining how findings about **Zachary**'s beliefs and practices changed after the use of videoclip interviews:*

Analysis of interview data independent of videoclips revealed Zachary's belief that effective learning takes place when teachers act as guides for students while creating a comfortable classroom environment. When asked about his teaching practices, Zachary said, "I sort of see my role as like, educational guide."… In addition to acting as a guide, Zachary believed it was important to create a particular kind of atmosphere in his classroom. While describing the group work portion of class, he said, "[It] is to just create a comfortable and friendly atmosphere." He also said that he thought it was ". . . good for them to feel like they have somebody on their side."

From what Zachary professed during interviews, it appeared he believed it was important to guide students through problems and act as "an intellectual resource" of information. These beliefs, combined with his views about the importance of a comfortable classroom atmosphere, could imply that in Zachary's classroom students receive help from him whenever they encounter something they do not know … it might also be inferred that he would provide rather specific information or suggestions to students as they worked on problems so they would not be uncomfortable and the friendly atmosphere could be maintained.

It would be easy to conclude that there were significant inconsistencies between his professed beliefs and what could be attributed to him based on observations of his classroom. Zachary's instructional practices did not involve "guiding" students to solutions to problems in the ways that might be inferred from what he said during interviews. When students were having difficulty with a problem, Zachary did not tell what the next step should be or point out what their mistake was. Instead, without fail, he asked them to explain what the problem was asking and to describe what they had done so far and why. In addition, while the classroom atmosphere was pleasant, Zachary sent clear messages about the intellectual work to be accomplished and his high expectations for students.

When data from videoclip interviews were used, analyses of data revealed what Zachary meant by terms he used and the perceived inconsistencies between his professed and attributed beliefs were resolved.

With Zachary, the key to resolving the perceived inconsistencies was unpacking his meaning of "guide." To Zachary, "guiding students" meant asking them questions to help them think about the problem so that they could devise a solution on their own. When we discussed videoclips where he was interacting with students in these ways, he was very explicit that his role was not to guide the students to a solution by telling them what they should do next or by identifying the particular mistakes they had made.

In describing his role as guide more generally, he said, "It's their [the students'] job to do the traveling and I can maybe just shine a light in the correct direction." While his use of the word "guide" fits well with these more detailed descriptions that emerged from discussion of the videoclips, this particular definition is not necessarily what might have been inferred from his earlier use of the term in the de-contextualized discussions about his beliefs.

Speer (2005, pp.382-385)

Of course, as with any research intervention, interview design is an inherently theory-laden process. In the case of Speer's videoclip interviews, the selection of excerpts, as well as the choice of questions, are all shaped by (and are a reflection of) the researcher's particular theoretical perspective. The choice of different excerpts could change the findings of the study. Therefore, from a methodological point of view, objectivity could be enhanced by having external experts, or the subjects themselves, validate the choice of video excerpts.

Conclusions and Implications

In this review of the literature I have outlined some of my concerns regarding the typical methodologies used in the study of mathematics teachers' beliefs and how they possibly lead to false attribution of beliefs: the reliance on verbal responses alone to questions posted at an abstract level; the use of de-contextualized interviews, questionnaires and pre-defined categorizations of beliefs; and the lack of shared understanding between researchers and teachers. These methodologies could also be behind the discrepancies between research and practice found in some studies. Researchers need to be aware of these issues and seek out methods that allow for the most accurate attributions possible. Since work on beliefs is highly dependent on descriptions and terms used by researchers and teachers, to improve the accuracy of attributions, as suggested before, researchers must aim for a maximum shared understanding of terms used to describe beliefs and practices as well as the context in which particular beliefs are being used.

CHAPTER 3

METHODOLOGY

This chapter has four distinct parts: (1) a description of the background and context for the selection of participants; (2) an overview of the methodology and procedures used to collect the data for the study; (3) an explanation of how the different data were analyzed to produce both the individual profiles of the teachers' beliefs and the description of apparent concordances and discordances between teachers' beliefs and research findings; and (4) a discussion of the limitations of the study.

Background for the Study

The Center for Learning and Teaching in the West

Funded by the National Science Foundation, the Center for Learning and Teaching in the West (CLTW) is a consortium of five universities collaborating with tribal colleges and public school systems in Montana, Colorado and Oregon. The Center brings the varied expertise of scientists, mathematicians, and educators together to address current challenges in understanding and improving student learning and achievement in science and mathematics from middle school through college. Work includes fundamental research and related activities focused on serving high-need populations in urban and rural settings. The Center supports an interdisciplinary research agenda, a doctoral graduate curriculum, in-service professional development and pre-service teacher preparation (CLTW web: www.cltw.org).

An overall goal of the CLTW proposal was to help the education community understand and enhance middle-level and high school student learning and achievement in mathematics in high-need populations within urban and rural settings. High-need populations, as viewed by CLTW, possess one or more of these characteristics: (a) high proportion of low-income families; (b) high proportion of minority students, including those with English as a second language; (c) low mean student test performance, or large performance variation with low income and minority students over-represented at low performance levels; or (d) inadequate teacher access to professional development and educational resources due to location (CLTW Strategic Plan, 2003).

CLTW Professional Development in Montana

The Center for Learning and Teaching in the West at Montana State University facilitates professional development for teachers on two reservations in Montana as well as in two nearby off-reservation districts. Teachers come from nine districts including seven public school districts, one parochial district that includes three distant schools, and one tribally run district. The main goal for the different opportunities offered by the CLTW professional development is to build a professional learning community of mathematics teachers from the area. The teachers involved in this study attended three different extended CLTW professional development opportunities described below.

Math Inquiry Group. The Math Inquiry Group (MIG) started in the spring of 2003 and continued until December, 2006. Each semester, based on the input of the participating teachers, the facilitators focused on a content standard from the Montana Standards for

Mathematics (Montana Office of Public Instruction web: www.opi.mt.gov). During the semester, teachers and facilitators met four times to explore research-based approaches for teaching that content standard. Activities were chosen from the National Science Foundation standards-based curricula and NCTM publications. Facilitators shared research from sources such as the National Research Council's reports *Adding It Up* (Kilpatrick et al., 2001) and *How Students Learn* (Donovan & Bransford, 2005).

Hewlett Packard Technology Project. With a supplementary grant from the Hewlett Packard Philanthropy Foundation, CLTW provided 26 mathematics and science teachers from the area with technology (laptops, printers, and internet connections). The goal of the grant was to encourage collaboration among participants and to enable them to participate in on-line classes. Recipients were required to participate in CLTW training on basic and advanced computer skills and the appropriate use of technology in the mathematics and science classroom. The project ran from the spring of 2003 to December of 2004.

Sharing Your Practice (SYP) Pilot. SYP Pilot was designed to encourage teachers from the Math Inquiry Group to deprivatize their practice, a characteristic of successful learning communities (Nelson, 2006). The pilot ran from September 2005 to May of 2007. The project was based on a combination of models for improving student achievement through teacher collaboration including a modification of *Lesson Study* (Stigler & Hiebert, 1999), *Backward Design* (Wiggins & McTighe, 2005), and *Critical Friends Groups* (Dunne et al., 2000).

The facilitators of these activities focused on mathematical inquiry, standards-based curriculum design, the appropriate use of technology in the classroom, and deprivatizing practice, but have not to date extensively presented or discussed research findings on best teaching practices for American Indian students.

Criteria for Participant Selection

Participants for the present study were selected using purposive sampling. The process used for the selection is explained below.

My relationship with the teachers involved in this study started in the fall of 2003 when I started attending, as an observer, several of the professional development meetings offered by the Center for Learning and Teaching in the West (CLTW). Later, I started co-facilitating these meetings.

Research indicates that high poverty schools have higher percentages of novice teachers, teachers without a certification degree and teachers who are teaching subjects in which they have neither a major nor a minor, and seldom remain very long in the school (Ingersoll, 1999; National Research Council (NRC), 2001, both in Kitchen, 2003). The teachers selected for this study are four exemplary teachers who break this stereotype of teachers in communities of poverty. This study focuses on the beliefs and practices of four teachers who have worked with high percentages of American Indian students from the same reservation for many years and were selected for this study for being exemplary teachers, dedicated in their efforts to reach Native American students in mathematics. These teachers have demonstrated deep concern for, and commitment to, improving their students' learning. Their

commitment is reflected, among other things, in their continuous attendance of all the professional development opportunities offered by the Center for Learning and Teaching in the West. Each of them attended all of the professional development activities related to mathematics on a regular basis since the beginning of the project in 2002. In all of these activities, teachers reflected upon their students' learning showing a deep concern and commitment to them.

Even though I personally selected and invited the teachers to be involved in this study, their participation was entirely voluntary. Teachers' names were kept confidential and pseudonyms for both schools and teachers were used throughout the study and final report.

Data Collection

To achieve the goals of the study, I gathered and analyzed different types of data including: (1) observation field notes from teachers' classrooms (summaries of each class, topic, intention, description of main strategies used, and short informal conversations with teachers); (2) classroom videotapes; and (3) transcripts of the audiotapes from individual videoclip interviews (external and internal). In this section I describe the data collection methodology and procedures. I start by giving a short overview of the data collection procedures followed by a more detailed description of the data gathering process and an explanation of the rationale behind my choices of data collection methods.

Data Collection Overview

As explained in Chapter 2, to investigate the beliefs of teachers regarding effective strategies for American Indian students in mathematics, I needed to use methods that avoided discussing beliefs at an abstract level by examining explicit links and connections

between moment-to-moment teaching practices and beliefs. The methods also had to facilitate the development of common vocabulary and the building of shared understanding of terms. Methods with those characteristics helped minimize researcher-teacher misunderstandings and false attribution of beliefs. Table 6 provides an overview and timeline of the data collection methods used.

Table 6. Overview and Timeline of the Data Collection Strategies

Data Collection Strategy	Strategy Description	Time/Duration of Data Collection
Classroom Observations	Observed teachers in their classrooms and took field notes to become familiar with teachers' strategy choices.	May 2007- 3 weeks (15 periods)
Videotaping	Videotaped each teacher in her classroom to later use excerpts of those videos as prompts in the second videoclip interview (*during classroom observations*).	May 2007 - 4 periods
Videoclip Interview #1	Explored teachers' definitions of the selected teaching strategies and got a "first read" of their beliefs regarding the efficacy of the teaching strategies with Native American students in mathematics.	May/June 2007- 60 to 90 minutes
Validation Interview	Gave teachers a first summary of their beliefs and responses to the first interview for validation.	June 2007 – 30 minutes
Videoclip Interview #2	Further explored teachers' beliefs with focus on the three selected teaching strategies.	June/July 2007- 60 to 120 minutes

Description of and Rationale for Data Collection Methods

In this section, I present a detailed description of the procedures that took place to collect the data required for this study. First, I explain how the observations and the videotaping were conducted. Then, I give a detailed description of the two videoclip and validation interviews, explaining how I prepared for the interviews, describing the criteria

I used for selecting the clips for the interviews, and how the interviews were conducted. For each procedure, I also explain the rationale behind my choices of data collection techniques and how they helped me to accomplish these goals.

Rationale for the Use of Videoclip Interviews. The data collection methodology used in this study is based on the use of videoclip interviews (Speer, 2002). This technique tries to address the concerns about methodology in research on teachers' beliefs that were identified in the review of the literature in Chapter 2. As explained in the literature review, the reliance on verbal responses alone to questions posted at an abstract level, the use of de-contextualized interviews or questionnaires and pre-defined categorizations of beliefs, and the lack of shared understanding between researchers and teachers are possible reasons for false attributions of beliefs. These factors could also account for the discrepancies between research and practice found in some studies (Thompson, 1984, 1992; Wilson & Cooney, 2002). By using videoclips of the teachers in their own classrooms as prompts for the interviews, it is possible to obtain information beyond what is possible in traditional, de-contextualized interviews or in a combination of interviews and observations. When asked to describe a videoclip, teachers provide the researcher with descriptive terms that have meaning for them, making it possible for researchers and teachers to generate shared understanding of terms. This method also addresses two other issues: (1) videoclip interview methods enable researchers to collect data on beliefs tied to specific examples of teachers' practices, and (2) data are generated that permit more accurate attributions of beliefs. The use of videoclips can help to build shared understanding by allowing vocabulary to emerge during the interviews and by providing a meaningful context for the discussions. Instead of

discussing beliefs and teaching practices in the abstract, videoclips provide concrete contexts around which discussions can be focused.

Description of Classroom Observations. In early May of 2007, before any interview took place, I observed each teacher in her classroom for three weeks, five days a week, one period per day. Observations in the teachers' classrooms were as non-intrusive as possible. While I observed the teachers, I took extensive field notes. The notes were primarily a running log of what happened in the classroom with some comments on particular incidents that were possibly worth exploring during the interview. I documented teachers' strategy choices with special emphasis on events related to the three research-based strategies selected for this study. Short informal conversations with each teacher, before and after each observed class period, helped to contextualize what happened in the classroom each day. I asked teachers questions about lesson intentions and asked them to briefly assess the lesson (did the lesson go as expected?). Throughout this stage of the data collection, the strategy I employed resembles ethnographic techniques for observation and field note data collection (Spindler, 1982). In my observation notes I tried to represent as faithfully as possible what happened in the classrooms, to help me better understand teachers' comments in the interviews. Also, observations were contextualized and I self-consciously deferred judgment, thereby allowing hypotheses and questions to emerge as the study progresses.

Rationale for Classroom Observations. Observing teachers in their classrooms gave me the opportunity to become familiar with classroom teachers' strategy choices and possible explanations for those choices. Familiarity with teachers' classroom practice helped

me to contextualize their commentaries in future interviews and facilitated the selection of clips from their own videos to be as "representative" of their teaching practices as possible. The decision of observing teachers' classrooms during the month of May was made for two reasons: (1) to allow time for the schools to complete all their state and national testing requirements in order to avoid putting more pressure on the teachers, and (2) to observe teachers toward the end of the school year when the classroom norms established in previous months are still in place but not interrupted by testing, sports or other major events.

Description of Videotaping Procedures. During the second and third weeks of classroom observations, I videotaped each teacher in her classroom while she was teaching mathematics. I did this for one period each day for four days, except for one of the teachers who, due to scheduling conflicts, I only videotaped three times. During the videotaping, the teacher was the focus, not the students. This study did not collect detailed information on students' behavior. The objective was to document what typically happens in the teachers' classrooms. Teachers were asked not to make any special preparations for the lesson or prepare the students in any special way.

All recordings were done with only one camera due to budgetary constraints and practicality. While using only one camera might limit the amount of information recorded in one class, it also simplified the analysis of the tapes by reducing the amount of video that would have been produced if more than one camera were used in the same classroom.

The process of videotaping was straightforward and followed similar procedures as the ones used in the TIMSS Video Study (Stigler et al., 1999). I positioned myself on one side of the classroom. The video camera was placed on a tripod and was turned on at the

beginning of the class and turned off only when the lesson was over. I followed two videotaping principles adapted from Santagata (2005) and Stigler et al. (1999):

- Principle #1: I assumed the perspective of a student in the class and pointed the camera toward what should have been the focus of the student at any given moment; and
- Principle #2: While trying to tape as much of what happens in the classroom as possible, the teacher was my main focus and I tried to capture everything the teacher did while conducting the class.

As with the observations, my presence in the classroom was as non-intrusive as possible. I sat by the camera, observing and taking notes and redirecting the camera only when necessary to follow the teacher.

Selecting External Videoclips (Preparing for Interview #1). Prior to the first interview, a series of research-based videoclips were selected representing the three teaching strategies examined in this study and identified by the research as effective teaching strategies for American Indians in mathematics (contextualized instruction; joint productive activity; and modeling). To select the videoclips I used three points of reference: the research-based definition presented in my review of the literature for each of the three strategies, a rubric adapted from the Standards Performance Continuum (Hilberg et al., 2004), and the Center for Research in Education Diversity and Excellence Standards rubric (CREDE web: http://crede.berkeley.edu).

The selected videoclips came from the research of Jerry Lipka based on the use of his *Mathematics in Cultural Context* modules (Lipka et al., 2005). All the clips are taken

from the same K-1 lesson taught by Nancy Sharp, a Yup'ik Alaskan teacher. As agreed with the author, no full descriptions of the clips or any transcriptions are presented in this paper but they all can be found in the article: *The Relevance of Culturally Based Curriculum and Instruction: The Case of Nancy Sharp* (Lipka et al., 2005). Besides selecting videoclips from parts of the lesson in which the teacher was using the three research-based strategies selected for this study, I also included other clips so that the teachers could follow the progress of the lesson from beginning to end. By doing so, I put the strategies used by the teacher in the video in context. Lipka's article validates my selection of videoclips. In addition, I also gave the research-based definition of the three strategies to a validation group and asked them to watch the entire video from which the clips were selected and to indicate (a) if they recognized the strategies, and (b) in which part of the video they occurred. The validation group was formed by a doctor of education and a doctoral student in mathematics education. They both selected the same time frames in the video that I had selected as clips for each strategy.

When I decided to use this Lipka video for the first interview, I considered the possibility that selecting a lesson of a K-1 teacher to use during interviews with upper elementary and high school teachers could be seen as a problem. I did consider that the teachers in the study could have trouble relating to a K-1 classroom setting, and thus in connecting what they observed in the video to their own practice. However, the quality of the video and the fact that all three strategies were used in the same lesson were overriding reasons to choose the video featuring Ms. Sharp for use. As the interviews proceeded, no concerns about this issue were expressed by any of the four teachers.

Rationale for the Use of External Videos. The reason for the use of an "external video" was fourfold: (1) to get teachers accustomed to talking about teaching strategies in a context less intimidating than talking about their own teaching; (2) to start off from the same point with each teacher; (3) to have the first reactions of all the participants to the same clips for comparative purposes; and (4) to build shared understanding by allowing vocabulary to emerge and by providing a meaningful context for the discussions. When asked to describe a videoclip, teachers provided me with descriptive terms that have meaning for them, making it possible for researchers and teachers to generate shared understanding of terms.

Interview #1 (Viewing External Videos). The first interview lasted at least one hour. At the beginning of the interview, and before watching the external videoclips, I explained to the teacher that I was going to show her a few clips from another teacher's classroom and that I was interested in her opinion on the strategies used by the teacher in the video. I provided transcripts so the teachers could more easily follow the conversation and reference specific parts during the subsequent discussion. Then, the teacher and I watched the selected videos together and the clips were used as prompts during the interview. After watching each of the clips of the unknown teacher, the teacher was asked for her impressions of the strategies used by the teacher in the videoclip and for the relevance that those strategies might or might not have for her own classroom. After each clip was played, I asked the teacher to answer the following three questions:

- What are your first impressions?

- Could you describe the type of strategies the teacher uses?
- How effective do you think the strategies were for her students?

If, after watching and discussing a videoclip, I noticed that an area of belief regarding the intended strategy represented in the videoclip had not yet surfaced in the conversations, I asked more direct questions to get that information. For example, "*Could you describe what the teacher is doing?"* or "*You mention that the teacher was doing the same task as the students, why do you think she chose to do that?*" During the interview, the teachers were encouraged to illustrate their answers with examples either from the video or from their own experiences.

On the second part of the interview, once all the clips had been watched and discussed, I asked the teachers to answer the following three questions for each of the videoclips:

- Would the strategies the teacher uses in the video be effective with your students?
- Which parts of the video do you find more relevant for you and your American Indian students?
- Which ones are the least relevant?

During the entire interview, the teachers were given the possibility to watch a clip again if needed. A copy of the protocol given to the teachers in the interviews can be found in Appendix A.

Even though a basic common interview protocol was developed for this interview, the researcher allowed flexibility to pursue issues raised by teachers as they discussed the clips. The discussion was used to build shared understanding by allowing vocabulary to

emerge. I did not talk about any strategy until it was brought up in the conversation by the teacher. If the participant's vocabulary or definition of a term differed from mine, then I adopted the participant's vocabulary or definition of that term during the interview and data analysis.

Rationale for Interview #1. Besides helping to build shared understanding and a common vocabulary, this first videoclip interview provided a "first read" of the teacher's beliefs regarding effective teaching practices for American Indians in mathematics. Also, this base of information was drawn upon to determine what types of teaching strategies to look for in the teachers' own videotapes when selecting clips for the second videoclip interview.

Validation of Interview #1. After reviewing the transcript of the first videoclip interview, a summary was written and a copy was given to the teacher during a 30-minute informal interview in which she was asked for her impressions of how the report reflected her comments from the previous interview. The summary followed the structure of the interview protocol. For each clip I summarized the teacher's first impressions, her description of the strategies used, whether or not the strategy was effective and why, and how it related to her students. During the validation interview, the teachers had the opportunity to read the summary of their own interviews and to validate and/or clarify how the content reflected their comments from the previous interview. After reading their own summary, each teacher discussed it with me. No additions, subtractions, or modifications were requested by any of the teachers. They all agreed to the validity of their summary.

The validation interview was done as soon after the first videoclip interview as possible, and the videoclips were available in case the teacher needed to review parts of them to put her previous comments into context.

Rationale for the Validation Interview. The purpose of these "member checking" interviews was to maintain accuracy. Asking the teachers for input on the written summaries validated the researcher's portrayal of teachers' beliefs and increased the accuracy of the final findings of this study by minimizing false attribution of beliefs.

Selecting Internal Videoclips (Preparing for Interview #2). After videotaping the teachers in their classrooms for four periods, I viewed the videotapes and selected excerpts from the video to use as prompts in the second videoclip interview. The selection of the excerpts was based on the teachers' comments from the previous interviews, on the data collected from the observations, and on the three strategies identified by the research as effective for American Indian students in mathematics. The goal was to select, when possible, clips that reflected practices that represent the teacher's characteristic way of engaging students in joint activities, contextualizing instruction, and modeling mathematical processes. I also tried to identify and select particular actions taken by a teacher that might have supported or contradicted some of the comments made by the teachers in previous interviews as well as the three teaching strategies identified in the literature. The number of videoclips selected for each teacher ranged from four to six clips depending on each case. Each teacher's practice was different and I needed clips that helped me to illustrate their

characteristic teaching practices and in some cases I included clips that related to their comments in the first videoclip interview.

To validate my selection of videoclips, after watching the clips, each teacher was asked to elaborate on whether and to what extent the excerpts selected characterized or failed to characterize her typical teaching practices. They all agreed that my choices were a faithful sample of their practice. One clarification was made by Julia on the reason why, in one of the clips, two students in the classroom were sitting separated and not together (this is further explained in Chapter 4). Due to privacy agreements with the teachers and the schools, no copies or transcriptions of the videos are available.

Rationale for the Use of Internal Videoclips. By using videoclips of the teachers in their own classrooms as prompts for the interviews, I was able to obtain information beyond what is possible in traditional, de-contextualized interviews or in a combination of interviews and observations. Teachers were able to talk about their beliefs in terms of their own teaching. When referring to a particular strategy, for example, they could point to a particular situation in the video when they used that strategy.

Interview #2 (Viewing Internal Videos). The selection of clips from the tapes recorded in the teachers' classrooms was used as prompts during the second videoclip interview. The interview questions were based on those clips and the comments from the previous videotape interview.

After watching each of the clips of her teaching, the teacher was asked to elaborate on the strategies she used in the video, and on whether or not, and to what extent the excerpts

characterized her typical teaching. For each clip the teacher was asked to answer the following questions:

- Tell me your first impressions.
- Could you describe the type of strategies you use in this video?
- How effective do you think the strategies were for your students?
- How typical was this clip in relation to your classroom practice?

After this initial discussion, the teacher was asked for clarification of possible concordances and discordances that existed between her practices and previous statements.

In the second part of the interview, once all the clips had been watched and discussed, I asked the teachers to compare their classroom practice with Ms. Sharp's as shown in the videos from the first videoclip interview.

Even though a basic common interview protocol was developed for this interview, the interviews were opportunistic. As in the first videoclip interview, I allowed flexibility to pursue issues raised by the teachers as they discussed what took place in the teaching episodes.

Rationale for Interview #2. The purpose of this interview was to identify teachers' beliefs with particular focus on the three teaching strategies selected from the research for this study. Teachers were given the chance to express their views about other practices that were important to them.

Validation Interview #2. For the second videoclip interview, no validation interview was subsequently conducted since the conclusions drawn by teachers' answers only

supported and expanded the beliefs that had already been documented and validated in the earlier interviews. Also, the teaching practices described by the teachers on the second videoclip interview were already validated by the teachers as faithful samples of their typical classroom practices.

Data Analysis

The nature of this study, an in-depth investigation into the beliefs and experiences of individual teachers, suggested a qualitative case-study design. Johnson (1980) described the case study as "unique in its potential for generating hypothesis or useful detailed information about learning or the instructional process." The study is a combination of exploratory and comparative case studies (Yin, 1994; Creswell, 1990; and Hawthorne, 1992). Also, the approach I used in the analysis at times resembled grounded theory, especially in the analysis ran to answer Question #2. In grounded theory, the goal is to generate a substantive theory (Creswell, 1998), to use "a systematic set of procedures to develop an inductively derived grounded theory about a phenomenon" (Strauss & Corbin, 1990, p. 24). A grounded theory study seeks to formulate a theory that accounts for the data, instead of setting out to test a hypothesis. Categories and explanations gradually emerge and evolve from the data as the study proceeds (Glaser, 1992 and Creswell, 1998).

In the section that follows, I describe the processes I used to examine the teachers' beliefs and practices individually and across cases. I explain how the data were analyzed to produce both an individual profile of each teacher's beliefs and a description of apparent

concordances and discordances between teachers' beliefs and research findings regarding effective teaching strategies for Native American students in mathematics.

Data Collection vs. Data Analysis

A significant amount of analysis was done while I was in the process of collecting data. For instance, the first summaries of beliefs written from the teachers' responses to the first videoclip interview and the data collected during my observations in the classrooms were used to select the internal clips used in the second videoclip interview. Therefore, before I drew upon that data to select the clips, a critical analysis had already been conducted to create the summaries of the first videoclip interviews and to decide which were the typical practices used by each teacher in her classroom.

Interviewing, for me, was also a part of the analysis process. I was constantly making decisions about which follow-up questions to ask or whether I should seek further clarification. While interviewing, I tried to never interrupt the teacher and, as she talked, my questions emerged from her comments. Once she had given an answer, I had to decide which questions to pursue and which to let go. Often, though, questions I thought I needed to ask to clarify certain comments or actions in the clips were answered by the teachers within the context of the conversation without me asking the question at all. This "groping for coherence about what is being said" (Seidman, 1998, p. 78) was an important aspect of the analysis process.

Analysis of Interview #1

Both first and second videoclip interviews were digitally recorded, transferred to a computer and transcribed by using an audio program that allowed the playback speed to be reduced. I first listened to them once and then I read through all of the initial interview transcripts without taking notes. Next, I read the interview transcripts a second time and recorded notes in the margin.

The analysis of the first videoclip interview provided a "first read" of the teachers' beliefs and was used to produce the first summary of teachers' beliefs. To analyze the initial interview, I began by coding the entire interview of each of the teachers individually. For simplicity and homogeneity among each of the teachers' summaries, I used coding categories that followed the structure of the interview protocol. I sorted the data by printing out copies and arranging them into various piles. The transcriptions including representative participant responses were grouped by hand. I first separated the responses by clip, simply grouping the responses according to the videoclip they were relating to. Then within each clip, I coded and grouped the responses, always by hand, into piles that reflected the following categories corresponding to the interview questions:

- teacher's first impressions;
- description of the strategy used by the teacher;
- whether or not the strategy was effective and why; and
- responses relating the strategies with her students and practices.

In addition, for each of the interviews, one coding was done across all the initial categories (clips). I grouped all the responses that talked about effectiveness of a strategy and created a fifth category for the teachers' understanding of an effective strategy (see Table 7).

Table 7. Coding Format for Videoclip Interview #1

CATEGORIES	TEACHER					
First Impressions	*Quotes*	*Quotes*	*Quotes*	*Quotes*	*Quotes*	*Quotes*
Description of the Strategy	*Quotes*	*Quotes*	*Quotes*	*Quotes*	*Quotes*	*Quotes*
Effective/Not Effective Why?	*Quotes*	*Quotes*	*Quotes*	*Quotes*	*Quotes*	*Quotes*
Regarding Teachers' Own Students & Practice	*Quotes*	*Quotes*	*Quotes*	*Quotes*	*Quotes*	*Quotes*
Meaning of Effective Strategy	*Quotes (All Clips Combined)*					

Using that structure, I grouped the responses in each category and wrote a summary of the interviews for each teacher. For each clip, I summarized the teacher's understanding of an effective teaching strategy, her first impressions, her description of the various teaching strategies used, why the strategy was effective or not, and how it related to her practice and students. As explained in the data collection section, the summary, including representative quotes, was given to each teacher individually during a 30-minute informal interview in which they validated how the content reflected their comments from the interview and my interpretation of their beliefs regarding effective teaching strategies for Native American students in mathematics.

Analysis of Classroom Practice

Classroom observation notes and video tapes were coded individually for each teacher. First, I used three initial categories based on the three teaching strategies selected

for the study, as well as a fourth one that emerged from the search for "typical practices." Other categories and subcategories later emerged from the data. Examples of these are some of the subcategories that emerged from the initially selected three strategies. In joint productive activity, for example, group competition emerged as a subcategory in two of the teachers' practices.

Analysis of Interview #2

Selecting Internal Videoclips. Once the first summary of beliefs had been validated and the classroom observations had been coded, the next step was to select the internal videoclips for the second videoclip interview. The goal was to include, when possible, clips that reflected practices that represented the teacher's characteristic way of engaging students in joint activities, contextualizing instruction, and modeling mathematical processes. I also tried to identify and select particular actions taken by a teacher that might have supported or contradicted some of the comments made by the teachers in previous interviews, as well as the three teaching strategies identified in the literature. In this selection process, I used the first summaries of beliefs validated by each teacher, as well as the classroom observation notes explained above in the description of my data collection.

While selecting the internal videoclips was based on the teachers' previous comments and my own interpretation of their classroom practices, their answers to the second videoclip interview, describing and analyzing their own teaching, validated my choice of clips as representative of their classroom practices, as well as confirmed and refined my understanding of their beliefs regarding the different strategies.

Analyzing Videoclip Interview #2. I began the analysis of the second videoclip interview by categorizing the entire interview of one of the teachers. I sorted the data by printing out copies and arranging them into various piles following the steps I will explain below. I then pieced together the themes that emerged into a coherent picture of the teacher's beliefs about effective teaching strategies for Native Americans in mathematics. I did this always searching for consistencies and apparent inconsistencies with what I had previously written as result of the first videoclip interview.

To start the analysis I first codified the answers to the second videoclip interview using four basic categories: the three selected teaching strategies and a fourth named "*other*." After the initial coding, I quickly discovered that in some cases these codes were too restrictive and I modified them as necessary to more accurately represent the data. This was apparent, for example, as I realized that the definition of a particular strategy was not the same for each teacher. In this fashion, new categories and subcategories emerged from the four initial categories. Also, categories that had emerged from the observations and the other data were explored and included if needed. I coded each of the teachers' interviews separately and then went back to each of them again incorporating new categories that had emerged in the different interviews. After I had completed the coding process for the first transcript, I reviewed the next transcript and tried to use the categories and subcategories in the analysis. I also categorized statements made by teachers with the categories that had emerged in the analysis of the observations. I continued this iterative process of coding and refining the codes as I worked through all the remaining transcripts and had saturated the categories. This process allowed me to check the validity of the different categories.

Answering Question #1

What are the beliefs of teachers who work with American Indian students in mathematics regarding the following teaching strategies identified by research as effective teaching strategies for American Indians in mathematics (contextualized instruction, teaching through modeling, and joint productive activity)?

The answer to this first question takes the form of four belief summaries, one for each teacher. Each summary resulted from the iterative analysis of the first summary of beliefs, the second videoclip interview transcripts with triangulation from the classroom observations analysis. I used the validated first summaries of beliefs and the classroom observation notes to check against my interpretations of the second videoclip interview responses. I also used the classroom videos as a way to further check and refine my belief analysis. I used this iterative, cyclic process as a tool for understanding and triangulating between the various data sources.

In the summary of beliefs presented for each teacher in Chapter 4, quotes from the interviews are used to illustrate the beliefs. Because of the way I selected beliefs to include in the summaries, there were multiple interview quotes to illustrate each belief. Some of the interview excerpts illustrated multiple beliefs. I chose quotes based on how easily I thought they would be for the reader to understand. All of the rich discussions with the teachers certainly contributed to my understanding of their beliefs. However, I tried to select quotes that illustrated the beliefs and in which I did not need to explain an excessive number of references or details to the reader. I often included references to the videos and descriptions of classroom practices to contextualize the quotes. In the summaries I did not separate but

merged and integrated all the different data sources.

Answering Question #2

What concordances and discordances exist between the beliefs of teachers who work with American Indian students in mathematics and research findings on effective teaching practices for American Indians in mathematics?

The answer to this question is a description of concordances and discordances existing between teachers' beliefs and research findings regarding the three research-based strategies emphasized in this study. To enhance the description, I included the rationale that teachers gave to support their beliefs which might shed light on the reason for possible discordances.

As mentioned above, in this phase of the analysis I used processes inspired by grounded theory. As in any grounded theory study, when I started I did not have any hypothesis about whether concordances or discordances existed between the teachers' beliefs and the research theories. I used the summaries of beliefs generated for answering Question #1 to find categories and subcategories of beliefs spanning all participants that facilitated the generation and refinement of themes that I could later compare and contrast with the researched-based definitions of the three teaching strategies selected for this study. As the analysis progressed, categories and explanations gradually emerged. Analyses associated with the grounded theory research tradition use the constant comparative method. This method of coding and recoding data throughout the data collection process informed that process and led me to categories, themes, and eventually theories to help describe and explain the concordances and discordances that appeared between the research and the four

teachers' beliefs regarding effective teaching strategies for Native Americans in mathematics.

Credibility and Study Limitations

In this section I discuss three possible limitations to this study: methodology adequacy, generalizability of the results, and positionality of the researcher relative to the participants.

Data Analysis Methods

Data analysis in qualitative studies is an iterative process of induction where themes emerge out of the data (Patton, 2002). In this study, interviews, observation field notes, and videoclips were coded and emerging themes categorized. The integration of the different data sources in conjunction with the iterative, cyclic methods adopted from grounded theory seemed particularly appropriate for the examination of connections between teachers' beliefs and practices and teachers' beliefs and research.

In keeping with my goal of writing an accurate representation of the teachers' beliefs, even though I used initial categories in the analysis of the interview and classroom observations, I also allowed different categories and relationships among categories to emerge. This seemed like the best approach to the analysis of this particular kind of data. The iterative, cyclic use of videoclip interview transcripts and the classroom observations and videotapes, as well as the various validations from the teachers, created many opportunities to triangulate the data. Lincoln and Guba (1985) suggest that qualitative research focuses on credibility in place of internal validity as a measure of trustworthiness.

Patton (2002) suggests that triangulation is one of the strongest methods to improve the credibility of a study.

In previous sections I addressed the benefits of using videoclip interviews and how they helped to minimize researcher-teacher misunderstandings and false attribution of beliefs. Of course, as with any research intervention, the design and use of videoclip interviews is an inherently theory-laden process. In the case of videoclip interviews, the selection of excerpts and the choice of questions are shaped by and are a reflection of the researcher's particular theoretical perspective. With that in mind, for the external clips used in the first videoclip interview, besides the validation given by Lipka's article (Lipka et al., 2005), I also used a validation group to compare the clips with the research-based definition of the three strategies and to validate my choices. For the internal videoclips used in the second videoclip interview, the selection was based on the teachers' previous comments and my own interpretation of their classroom practices. However, their answers to the second videoclip interview, describing and analyzing their own teaching, validated my choice of clips as a valid sample of their typical classroom practices.

Generalization Limitations

Research design involves compromise. By focusing on only four teachers, this study of teachers' beliefs regarding teaching strategies sacrifices breadth of representativeness. To what extent can the findings of this study, assuming they are valid, be generalized? How representative are the experiences of four school teachers? Regarding single teachers, individuals differ across time and location. Furthermore, one individual's strategy choices might vary within the same classroom across units and the course of a school year. My

ability to capture the whole scope of a teacher's strategy choices in any of the four classrooms is limited by time and resources. However, 15 observations (one class a day, five days per week for three weeks) provide a solid foundation to contextualize and support teachers' interview results. Regarding the group, the sample in this study includes Native and non-Native teachers, elementary and secondary teachers, teachers with many and few years of teaching experience, and teachers from off- and on-reservation schools. This helped to capture multiple perspectives regarding how different teachers, with different personal and professional characteristics, understand teaching strategies deemed effective for their Native American students in mathematics. The effect of having multiple cases across a number of important variables provided additional insight. However, despite this variation across cases, the teachers' beliefs cannot necessarily be generalized beyond these teachers and their contexts.

Researcher's Position Relative to the Participants

In case studies of individuals, data collection revolves around the key informant, and the risks of bias and distortion are significant (Hawthorne, 1992). These risks may be further accentuated by the key informant's relationship with the researcher.

As mentioned before, my relation with the teachers involved in this study started in the fall of 2003 when I started attending the professional development meetings offered by the Center for Learning and Teaching in the West (CLTW). I was a new doctoral student and doctoral fellow of CLTW. The close relationship that had been established between the teachers and the CLTW facilitators was invaluable to help me gain the acceptance of the teachers who made me feel welcome from the very beginning. In September 2004, I became

part of the CLTW professional development group. I have been facilitating professional development in several different CLTW projects for the last two and a half years.

My familiarity with the participants may influence the interpretation of some of the teacher comments and/or behaviors in the classroom. Also, my function as professional development facilitator could be seen as a position of power that might influence teachers' responses to my questions and their behaviors in the classroom. However, the trust built between us also encouraged honesty in their interview responses. The teachers in this study know me and are comfortable with me. During the three years working together we have enjoyed each other's company. We have also learned together and from each other. The literature is clear on the importance of trust between members of a professional learning community that is attempting to increase student achievement (Kochanek, 2005; Nelson, 2006) and the creation of a trusting relationship between the teachers and the CLTW professional development facilitators has always been the base of our work with teachers, including the participants in this study.

An important characteristic of this study is that it does not try to prove any hypothesis. This facilitated the objectivity of the conclusions regarding teachers' beliefs and their concordances and discordances with the research. Rather than judging, the intent of this study was to faithfully articulate the beliefs of four teachers regarding effective strategies for their Native students in mathematics.

Aspects of the Researcher's Bio Connected to the Credibility of the Study

I was born in Spain and I had lived there for 25 years when I moved to Oulu, Finland to get my Master's degree in mathematics with a minor in education. I did my education

studies through the Education International Program offered by the Department of Education of the University of Oulu. The program has strong emphasis in multicultural education issues. During my teaching training, I also student taught mathematics and physics at two upper elementary classrooms in the international school of Oulu, and mathematics in two high school classrooms from the International Baccalaureate program. In all cases, the student population was culturally diverse. In the United States, during my doctoral studies, I also student taught for a school year in a mathematics classroom, with fourth and fifth graders at Irving International School in Bozeman, Montana. As in the schools in Finland, the cultural background of the students in the school was diverse. These experiences as an international student in Finland and in the U.S., learning new cultures and languages while studying mathematics and mathematics education, and teaching students who were culturally and socio-economically diverse helped to prepare me to conduct this study among teachers and students who must bridge traditional and contemporary Native American cultures and mainstream American culture on a daily basis. These experiences contributed to my ability to be a more culturally aware observer and learner during this study, which in turn helped me to become a more culturally responsive instructor in the faculty position I now hold at an international university in Madrid.

CHAPTER 4

TEACHERS' BELIEFS

In this chapter information from all the data sources collected in this study will be combined to answer the two research questions.

Question 1

The first question this study attempts to answer is:

What are the beliefs of four teachers who work with American Indian students in mathematics regarding the following teaching strategies identified by research as effective teaching strategies for American Indians in mathematics: contextualized instruction, teaching through modeling, and joint productive activity?

To answer this question I present a description of the beliefs of each of the four teachers regarding effective teaching strategies for American Indian students in mathematics. I start by giving the teachers' definitions of "effective strategy." Then, for each teacher I present a summary of her beliefs regarding each of the three teaching strategies considered by the research as being effective for Native Americans in mathematics. Teachers' quotes are given to support the summaries of their beliefs. All the quotes included in the summaries come from the first and the second videoclip interviews. At the end of each summary, I include other teaching strategies identified by the teacher as effective for their Native American students in mathematics.

The Teachers and the Schools

Four teachers were involved in this study, two elementary teachers from Burton Intermediate School and two mathematics teachers from Mountain High School. Ronda and Laura, respectively teach at the fourth and fifth grade levels in Burton Intermediate. They both have seven years of teaching experience. Burton is an off-reservation border town. Burton Intermediate offers third, fourth, and fifth grades, with 59.0% of the student population American Indian and 33.1% White. Ronda is American Indian; she was born and still lives on the reservation adjacent to Burton. Laura is White and lives fifty miles from Burton in the largest city in the state. They are both young teachers and have always taught with similar student populations.

Julia and Teresa both teach mathematics at Mountain High School, a school where 100% of the student population is American Indian. Mountain is the largest town on the reservation. Teresa is American Indian and lives in Mountain while Julia, who is White, lives there during the week and returns home in a town off the reservation for the weekend. Teresa and Ronda speak their students' native language but they both teach in English.

Ronda

Ronda teaches 4th grade at Burton Intermediate. She has fifteen students in her classroom, about half of them are American Indians. Ronda is American Indian; she was born and still lives in the reservation. She has been teaching in Burton Intermediate for the last two years. Before joining the Burton staff two years ago, Ronda taught for five years in a multiage classroom at a small, predominantly Native American school in another town on

the same reservation.

When Ronda talks about teaching strategies being effective she talks about engagement and about students being focused, hooked, and on task. She also thinks a strategy is effective when students are connecting new concepts with their lives or when the strategy helps students to develop thinking strategies.

Ronda's mathematics classroom has a well defined structure. On most days, she starts her mathematics lesson by introducing the concept they will work with that day. After the introduction, students spend the rest of the period working on an activity related to that concept. On most days students work together in groups of two or four on activities related to the new concept. Some other days, students work individually on worksheets. Ronda starts most of her mathematics classes the same way; she sits on a high chair by the transparency projector located at one side of the classroom,. Her students have taken their chairs and are sitting in front of her in a semicircle.

Normally, Ronda introduces a concept by talking about something that is familiar to the students and relates this to the mathematical concept. One day for example, she was introducing a lesson in fractions using a hexagon subdivided into six equilateral triangles. She started the lesson by asking the students if they had ever made a quilt or seen somebody making it. Students immediately started talking about their mothers and grandmothers and other stories related to quilts. Then Ronda talked about her grandmother's quilt and how its pattern mostly used triangles. She also told them that they could go to the library and see many different quilts. After talking like that for a while, she used some transparent triangles in two different colors to form a hexagon. She made different combinations and asked

students which fraction of the hexagon was represented by the different colored triangles. Using manipulatives to model a concept is very common in Ronda's introduction of new concepts. Normally, after the introduction, students go back to their tables, which are organized in groups of four, and work either individually or in small groups. After the introduction to fractions in a hexagon, for example, students went back to their tables and worked in pairs on an activity involving a fraction wheel.

This year Burton Intermediate has adopted the Accelerated Math Program[1] and Ronda has to devote part of her mathematics period for students to work on it. Students work in Accelerated Math a few days a week. The time devoted to it per period depends on the students' progress and it might last from 10 minutes to the entire period.

Contextualization

Ronda believes that connecting mathematics with her American Indian students' lives is definitely an effective teaching strategy. She thinks when students make connections between the mathematics they learn in the classroom and their daily lives, they learn better. After watching the video in which Ms. Sharp is talking about some patterns in a Yup'ik parka and comparing the triangular patterns with the mountains that the students can see from the window, I asked Ronda whether the strategy used by the teacher in the video would be effective or not with her Native students in mathematics.

[1] ***Accelerated Math*** *is a daily progress software tool that monitors and manages mathematics skills practice from first grade mathematics through calculus. It is published by Renaissance Learning, Inc (http://www.renlearn.com/am/). Accelerated Math generates individualized assignments and tests, corrects assignments and tests, and records and reports results for immediate feedback. Each assignment or test is based on data from assignments. Students are responsible for completing assignments and tests, reviewing incorrect answers, setting appropriate goals based on their abilities (with teacher assistance), and discussing progress with the teacher. The student will be eligible to test on a mathematical concept when he/she has correctly answered a set number of questions about that concept.*

> The kids... like my kids, they all know what different things look like, and somehow the school has to make the connection from [things in school] to things that are outside…. I think [the strategy] definitely is [effective], I mean, just like [in the video] she talked about how some of those shapes looked like the mountains and then how she named those rivers in her design in her pattern…. I think kids relate to that, when they see things in real life.

Ronda believes American Indians have always learned in context and it is still a valid strategy today.

> In my culture [Native American], long time ago, my ancestors learned as much or probably more than I but it was at a different time and in a different world… All the things that they learned, they made connections to their world… I mean, I'm sure that children that age, long time ago, 150 years ago or 200 years ago, when they were learning things, their mentors, or whoever was teaching them, were showing them things outside that made that connection so... I think that [most] Native American learners still learn like that… I think that, when they really make that connection to things outside, it makes more sense to them...

On the other hand, Ronda thinks American Indian students find it hard to relate to concepts and expressions that are not familiar to them and their context. After watching a video of herself in a lesson in which she drew fractions of a circle and then used different types of fraction models, like stripes on a field ready to be planted, Ronda said:

> If they just see the picture that I draw, the circle with the 5ths and then the other one, if they could just look at it and see it, I think it clicks but then when I ask them how many 5ths are up there… just that whole language, 5ths.... That is not a word that is regularly used in their terminology at home. I know that in many languages, in the communication at most homes, especially Native American, they don't use fractional terminology. Now, me and my husband, we are talking about something and I'd say "a third of it, or a fourth of it." And sometimes my kids will say "what do you mean?" And I'd say "well, that bucket, fill it up to at least 1/3 full" or something. However, I don't think that is as common [in other homes]. Not that there is anything really wrong with that… it is just not a common concept or aspect in the Native American language. There was no set measurement, like number wise before. They used measurement but they used their fingers, or hands, or lengths…

However, Ronda believes there is a way to get students to become familiar with such concepts by relating them to things on their environment, to make a connection to something

they know so that the new concept does not sound so foreign to them.

> If they are not going to get it [the fraction vocabulary] at home as much, I guess I need to reiterate it or to get it to the kids throughout the year with little tiny things that I do in the classroom. If I try to use it as much as I can in the classroom, like I do at home, and then give them examples, little tiny things, like if we go outside, and I tell them, for example, that 3/4 of our line is going to go outside earlier. If I just use it more...

In her classroom, Ronda tries to connect each mathematical lesson with her students' lives. However, Ronda feels as though that she does not connect mathematics and her students' lives as often or for as long as she thinks she should. She says it requires an effort from the teacher to constantly remember to find something that relates the content to the students' lives. She also finds there are limitations to what she would like to do (taking them for walks, etc.) Some of the limitations include lack of time and the vast amount of content they need to cover.

> It takes some effort to do that and you have to think about it… It has to be on the back of your mind all the time. But you got so much to get through, one lesson and then on to the next one, and then the routine. And all you do is trying to get through it.... It takes some time to really think about it "What's something in this little lesson that I can connect to?" And it doesn't even have to be a picture or taking them out on an nature walk, it could even be a story.... When somebody tells a story to those kids... is like that human to human... they just start listening to you right away.... We did lines of symmetry one time and I took pictures out of a magazine and then I asked the kids. I couldn't go outside but I really wanted to take them outside and just take them all over the place and let them look for all these different kinds of lines.... Somehow, we were able to do that with the magazines, it kind of connected but.... If I were able to take them out on a little walk, that would connect so much more, because every time they would drive by that traffic sign, for example, they would say "oh, that was a line!" It would be ingrained in them; that's what really connects.

As mentioned before, Ronda often uses real contexts to introduce new mathematical concepts. However, it is important to analyze this in more detail. One day, for example, Ronda started a lesson talking about tile designs in mosaics. She first presented several

designs and asked students for places where they might have seen similar designs. Among other stories, some students talked about how they had seen mosaics like those in the bathrooms of some restaurants. Then they moved on to the worksheet which was about counting the shaded squares on a 10x10 square grid and calculating the fraction of the whole square grid represented by the shaded squares. They never returned to their discussion of mosaics. While the teacher in the videos from the first interview, Ms. Sharp (Lipka et al., 2005), takes a real context (the pattern designs on a Yup'ik parka) and builds an entire unit around it, embedding the mathematical content into it, Ronda embeds the context into an already built unit using the context to introduce the new mathematical concepts and then moving away from it. When asked about this difference, Ronda said she believes that building the whole classroom around a real context, embedding the math concepts into it, would probably be more effective for her students than just using the context as an introduction.

> I think [is more effective] when it all connects, when it all has a central theme. I think the strategy in my classroom is.... I will center all around the mathematical concept that I am trying to get across.... She had a mathematical concept [geometrical patterns] but she integrated the math concept with the parka. Where with mine, I think I just focus more on the math concept. I integrate the outside world into the math concept, using the mosaic [for example] but still focused on the math concepts.... I think what she did would be more effective. She had that theme where it connected to the parka and it came back around. They started with the parka and at the end of the lesson they were all making patterns that represented the river and the mountains in their area but it was all connected back to those geometrical patterns.... It would be better because the kids can connect to something. When they left the classroom every time they see a parka they are going to think of those triangles in a mathematical way, they are going to think of using geometry, they are going to think of that, it will always be there, it will be ingrained, they will always make that connection.

Ronda said that there are times when she manages to build a whole math lesson around a context. She gave an example of a lesson she teaches on the Thanksgiving Holiday, related to addition with decimals.

> I do it with money for Thanksgiving. I give them each a paper brown sack and I give them ads from where they cut out those things they want to shop for Thanksgiving. They buy them from me and then glue them on to their paper sack. That is when we do adding and subtracting decimal numbers so it kind of makes the connection there.

Once again, time seems to be an obstacle to implement the strategy in the way she really would like to.

> It takes a lot of preparation and a lot of time before you even teach.... I could come up with a piece of mosaic art work but it is not something that they are very familiar in their surroundings. I really would have to think about something that I could bring into the classroom so they could make that connection like a beaded loom pattern for example... like different beaded hat bands. If you could think of those like a pattern then they could connect to the math.... I think I could incorporate something like that… but it takes a lot of time and you have to put a lot of time and preparation before you can use it. But like Mrs. Sharp's was so simple, she just used the parka; she just brought it in.

Another limitation that Ronda has found is that, even though she believes nature is the greatest context of all for Native American students to learn and connect to mathematics, she believes that children are less and less exposed to nature these days, and she believes this might limit their ability to relate mathematical concepts with their daily lives. She thinks schools have to somehow provide that experience for students, giving them the opportunity to be outdoors and to really connect to their environment.

> Once somebody told me “when you think of the horizontal line, think of the horizon.” When I was a little kid riding outside with my dad or my sisters, looking up to the mountains, that scenery and that sun coming down, almost dark in the evening… whenever I think of a horizontal line [Ronda clips her fingers] that picture comes to my mind! Now, whenever I’m teaching horizontal and vertical lines, I draw a long line on the board and then I try to make the sun. I try my best but that picture

> is not anything to my picture. My picture came from my experience from outside. I see a lot of my students lacking that... they didn't have a lot of opportunity to be outdoors, to really connect to their environment. When I think of my experiences with anything related to the outside world and I compare that to even some of my elders, or people older than me, is like they even have more than I do, I know they do… and when I compare to generations younger than me is less.... I see it diminishing in ways.... I think schools and teachers have to give that opportunity for the kids if they are not getting it at home.... Learning has to be not just in the classroom, it can be out of the classroom. I think we can bring in things to help us connect to the outside just like the lady [in Ms. Sharp's video] brought in her strategy those mountains... and she asked the kids to think about that grass.

Modeling and Demonstration

On one of the clips from Ms. Sharp's video (Lipka et al., 2005), the teacher asks students to make a square out of black construction paper. The students struggle and are off-task until she decides to model how to do the first fold. Once she starts modeling, they begin observing and stay on task. After watching the clip Ronda said:

> The teacher went into this fold "how can you make a square with a fold?" She modeled; she took that one square and show them that straight line. I think once she showed them the straight line, the kids were able to look at that one square and then they were able to fold, to fold those pieces back underneath. I think when she did that fold it kind of prompted those kids to start that fold.... [They were so distracted] and once she started showing them that straight line the hats just drop, they just drop… the kids are now given the opportunity to go on and model.... They are being asked to make a square and they were ready and they were waiting. I mean, the kids were all ready to go and as soon as she allowed them that opportunity to model the square they just... the hats just drop they were engaged right there… one would start folding and pretty soon they were all engaged.

In her classroom, Ronda models both the procedure and the thinking process. Ronda believes that modeling both the strategy to solve a problem and the appropriate working behavior is a very effective way of teaching math to her American Indian students. She says she tries to do it, and examples from the classroom bear that out. Most of the days observed in Ronda's classroom she started the class by modeling. But, according to her comments, she

does not always do it because: “it would be ideal to have every lesson something for the students to model, but… you go back to that time again, I mean, you only have your precious 60 minutes right there. It’s that time again.”

She believes that, during the five years prior to school, kids gain a vast amount of knowledge by modeling, and she thinks this would be the natural way to teach them in school.

> From the time they are born till the time they went to school, there was so much that that child learned from birth to 5.... They learned how to walk, they learned how to eat, they learned how to behave, they learned how to speak. Before they come to school, they have this enormous amount of learning from mom, they watch dad, they watch brothers and sisters. And they were never given the type of instruction they have in public instruction… how did they learn it? They learned it by modeling, by watching, by hearing, and by doing. So, obviously, that worked.

In one observed class, Ronda did an activity in which her students had to represent different additions of fractions (one fourth plus two fourths, etc…) with colored cubes using as a guide a fraction strip representing the whole. Ronda thinks that using concrete and visual models of numerical and abstract concepts is a very effective strategy for her Native American students. She believes that Native American students often need to see a model of the concept before they can move on to the abstract.

> This one I am allowing the kids to come up with their own fractions, to figure it out by looking at it. I gave all the kids simple addition problems. They all had sets of tiles, colored sets, and I asked the kids to model each of the sentences. In the case of Sandra [a non-Native girl], obviously she doesn't even need the fraction strip, she can just look at it, and she already knows. Not only does she know the denominator has to stay the same, but conceptually she already understands it, she can picture it her mind. But a lot of them still needed to see visually those fraction strips to add them.... They really use the one whole strip at the top as a guide cause I think a lot of my Native American students especially, when they see that whole strip at the top then they use it as a guide, because when they put four sixths up there and add two sixths then they can see how coincides with that being a whole.

Instead of letting the students just figure it out, Ronda modeled a couple of examples first. She believes that most Native American students need to see an example of the task they are to perform before they attempt to do it.

> I think I did it [giving them a couple of examples before they started] more for the students that don't know how to model you have to model, model using the fraction strips.... My students that have a hard time understanding, they need to see.... And in my classroom is hard to say but I think a lot of the ones that have more difficulty are definitely all Native Americans, not all Native American students, but out of that group having difficulty they are mainly so I almost have to say that most Native American students have to see. But there are those ones in my classroom [se included four names] that don't have to see. But I think generally they have to see.... I think, I use fraction stripes and other model representation for fractions, because in the past I found that with fractions and the whole set, the way we learned it, just jumping right to the numbers and right to the words but especially numbers… that didn't click for a long time for me until I saw shaded areas or shaded circles or bars or whatever. When I saw that then it clicked. I know for a lot of my Native American students that clicks. So I think when I introduce that I wanted them to see the square grids and the diagram the model then go to the number.

Sometimes Ronda deliberately avoids modeling tasks for her students. During another lesson regarding fractions, Ronda gave her students a new set of fraction cards. On each card was a square grid divided in one hundred smaller squares and each card had a different fraction of those squares shaded. The first thing Ronda asked the students was to try to find patterns among the different cards. She did not give any more clues but let the students come up with their own ideas like “as the number of shaded parts gets bigger, the non-shaded get smaller.” Ronda thinks that there are times when *discovery* is a very good strategy. She believes that when students discover something on their own it sticks better in their memories. She believes though, that inquiry has to be timed and focused. If students are not given enough time they will get frustrated and give up, but if they wonder for too long soon they disengage and get off task. You also need to narrow the goal and make it very

clear or it will be overwhelming and then again students will give up.

> When they find it, it stays in their mind where if it is just given to them then I don't know if it will stay in their memory or their thinking as much.... When you give them the time to discover you also have to sneak in the time frame. Cause if you just give it to them to discover, no matter what it is and your time frame ranges anywhere from a too short amount of time to it being too long of a time. That can loose that discovery. I think it was effective; they come up with their own pattern that they see.... Also is good when I give them something like a clear focus or a goal to reach within a certain amount of time "I am going to give you 2 minutes to find 2 or 3 tings you see in all the green cards" or whatever… then they are looking for something concrete, they are not just playing, they are actually looking for something, they have to find something within that time. It wasn't a game but yet there is a little bit of competition in there. Cause I could see how each team wanted to find a pattern first.

While watching herself on the video with the fraction strip and the cubes, Ronda realized that she was getting impatient to quickly and helping students too much. Ronda believes that letting her students think and develop problem solving strategies on their own is a good strategy for her Native American students in mathematics but again she has trouble finding the time to do it. She thinks that the pressure to cover a vast amount of material each year, together with the little time devoted to mathematics in the week, might be getting in the way of her letting students discover and come up with their own ideas.

> I had my hands in there a lot when they were sorting them out, trying to line them up with the one strip… I should have let them.... Sometimes it is hard as a teacher because you just want to do it and you are kind of not allowing those kids to think and problem solve. You just do it all the time and then you do not allow them to do that process of thinking.... It could be time and how much you want to get through in the lesson. It is easier just to get it done… that's how I get sometimes I rather just get it done on my own and sometimes I really have to think about am I really allowing the kids to think about it or am I doing it for them? I know definitely there is more stress level compared to language arts. Also, language arts it is from 12:05 to 2:00, and that is a big chunk.... Our math is one hour except for Tuesdays when is only half.

Joint Productive Activity

Ronda often has students work in groups. During the observations, she did not get involved in the same work as the students, as Ms. Sharp does in the video, but she did consistently ask students to work together for a common goal. She sometimes placed students in small groups that competed with each other and other times placed them all together to try to solve a certain problem.

Ronda really liked the strategy used by Ms. Sharp on the video where Ms. Sharp sits with the students and works on her own pattern. The deep level of students' engagement is what Ronda sees as indication that the strategy works for Ms. Sharp's students. She believes that the teacher being there, sitting and working with her students was key to the students' engagement. Ronda thinks that the strategy is also a way to model both the strategy to make the pattern (the goal of the lesson) and the appropriate working behavior.

> She was working on a pattern on her own but she was also talking to the kids.... Just her, sitting on the floor with the kids.... I'm sure the kids have to be looking at her pattern too, is like she was doing it with the kids.... She modeled to them... that sitting down and working on that pattern. I think that definitely had an impact on the atmosphere right there.... It was so quiet and the kids were doing their own things.... If she would have gotten up and did something else... or even if she would have gotten up and walk around... that wouldn't even had to do it.... I think it would have differed from what she did right there.

Ronda had never tried that strategy of sitting with students to work on the same activity. In fact, it had never occurred to her. She thinks it would be a good strategy to use with her American Indian students and she is eager to try it in the future.

> I try to make that effort of trying to get around. I get up and move. I walk around.... I try not to ever seat at my desk during the classroom. I really make a habit of moving around and walking around but that alone isn't enough, I don't think.... Watching her, she sat there and she did the same thing that the kids were doing, and that's something that I need to do more of.... I never thought of it.... I just didn't.

Reflecting about a fraction game Ronda had her students play when I was observing, she mentioned that maybe an approach similar to the one on Ms. Sharp's video in which she sits and joins the students in the task would have been beneficial.

> When you were in my classroom and we did the games with the decimals and fractions maybe if I would have gone and sat with one group as a member and play the game while keeping an eye on the other groups like she did, maybe play one round and then go to another group and play another round… Maybe that would have kept them more focused.... I think that makes a difference… because the kids want you over… They probably want you to play with them and be part of their team.

In one of the observed and videotaped lessons, Ronda grouped students and gave each group a container with colored cubes. Each cube represented a hundredth of the whole. Ronda then read out loud a fraction or a decimal number and students had to model it using the cubes. The group that finished first each time got a point and the one with more points at the end was the winner. During the activity, students were excited and on task, and they celebrated how the time they used to finish was getting shorter even if it was a different group who finished first. Ronda thinks that group games and competition are very effective with her students.

> I think I used more the strategy of a game out of it and it was somehow timed. I didn't time them but they were against time to be the first group. They were doing it individually [as small groups] but more as a team. So they were all helping one another. I don't know.... I have heard people say that you shouldn't be embracing so much the competition but it works!

When asked about individual competition, that is, students competing against each other individually, instead of in groups, Ronda does not seem to find it as effective for her American Indian students:

> I have done that before in math and different content areas. What happens is that the top one third group, the elite group, will come out and then the middle section, and

> the ones that are having difficulty pretty soon they start losing engagement in the competition. They either don't want to compete or their interest kind of loses, shuts down if the competition is individually.

Ronda sees some limitations to the implementation of group work and games in her lessons. Some are setting up the teams and time.

> I think [it works] for the most part. And I think the key to that is the management as far as setting up the teams. For me, I don't hardly ever remember a time when it was perfect, that almost never happens because there are so many different personalities. I mean, it is a good strategy and obviously the kids like it but… you are always going to have a couple of those that are dominating or some that just don't care too much.... It works quite well though and students are learning from each other. But I have to admit that I am lucky if I can get some games in once a week, time again.

Other Strategies

In Ms. Sharp's videos the whole lesson is taught in Yup'ik, the native language of the students. The students speak English among themselves and both languages with the teacher. Ronda is fluent in Crow but she teaches always in English. She was very impressed about Ms. Sharp's use of the students' native language (Yup'ik) in the classroom. She thinks is a perfect way to preserve the language. However, she does not think her students would feel as comfortable using their native language as the students in Ms. Sharp classroom do. She thinks her students are very self-conscious about making mistakes and they will feel afraid to say something wrong. She does not think, therefore, it will be an effective strategy to use their native language in her mathematics classroom.

> I was amused about the language.... Somehow they are holding on to it and that would be interesting for us too because our language is really dying fast.... You can tell that she is really reinforcing that language so when she says the name of those rivers those kids just said it right away! I think that is so neat because she is keeping that language.... If that was our home [our school] and somebody had come in and if they were to say that in our language… most of the kids are real uncomfortable with having to speak in Crow because they might say it wrong or they might sound

> funny or the others might laugh at them or something but that group [in the video] they are just .more comfortable.

Summary

Ronda's understanding of teaching strategies is strongly influenced by her cultural background as well as previous personal and professional experience. Her implementation of the strategies is greatly constrained by the time structures imposed by the school system. The following bullets capsulize the main points of Ronda's summary of beliefs:

- A strategy is effective if promotes student engagement and the development of thinking strategies, and if it helps students connect new concepts with things they know.

Contextualization:

- In her classroom Ronda builds her units around a mathematical concept and imbeds familiar context into the unit to introduce the concepts; then she moves on.
- It is an effective strategy because when students make connections with their lives they learn better.
- Building units around a context, imbedding the mathematics into it, would be a more effective strategy but is time-consuming and requires the teacher to get out of her comfort zone.

Modeling and Demonstration:

- In her classroom Ronda models both procedure and the thinking process involved in solving simple tasks and procedures.
- It is an effective strategy because:

- children have learned my modeling since birth;
- it has always been the traditional way of learning for Native American; and
- Native Americans need to see the tasks they are to perform.

- The biggest limitation to the use of modeling in her classroom is that it is very time-consuming
- The opposite of modeling is *Discovery*: students perform a task with no guidance or previous modeling from the teacher.
- Discovery works only if is timed and focused.

Joint Productive Activity:

- In her classroom Ronda often puts students to work in groups and does group competitions.
- Both group work and group competition are effective because students get very motivated and help each other to find new problem solving strategies.
- Ronda's group competition strategy is very similar to joint productive activity as defined by the research literature, except for the teacher's involvement.
- It has never occurred to Ronda to work in the same activity as the students; it could be a valid strategy and she is eager to try it.

Laura

Laura teaches fifth grade at Burton Intermediate. She is White and lives in a much larger city, 50 miles away from Burton. She commutes each day. Laura is a young teacher, in her twenties. She has taught for seven years, always at Burton Intermediate. Laura does

not speak any Native language and teaches in English.

Laura talks about a teaching strategy being effective in terms of students being on task and following along. She talks about strategies that help students understand, learn, and memorize concepts better as well as strategies that make the concept taught relevant to students and help them to make connections between different concepts.

As in Ronda's case, Laura has to devote part of her mathematics period to Accelerated Math a few days each week. The time the students work in the program might range from 10 minutes to the whole mathematics period, depending on the students' progress.

Contextualization

Laura believes that relating mathematics to the students' lives is an effective teaching strategy for her Native American students. She believes it helps students to see a purpose for what they are learning, sparks their interest, and helps them to make connections with what they already know.

> Relating what they are learning in the classroom to something that they know outside the classroom is very important. It helps them [the students] make connections and I think it motivates them to want to go to higher levels in math "I understand that I am going to need this, so now I am going to wonder about it." I think as they build, they start thinking even in higher levels and want to problem solve different things. By talking about those examples, when they go home they probably will start seeing math more in their life. Or in their parents lives "Oh my goodness! Mom was at the grocery store and she did have to do that"; or "Oh, we did drive all the way to Bozeman and we did have to fill up the gas tank twice, so we must have used this many gallons of gas!" They start seeing math working outside of school and I think that is a great motivator. Them paying attention in classroom and striving, and making goals and even coming up with their own questions and their own answers to their questions mathematically might be worth it.

Laura believes that connecting students' lives with the mathematical concepts she teaches is a great motivational tool that gives students a reason to study and adds value to school. Laura sees this as an especially important asset in her school since many of her students come from areas with high rates of poverty and unemployment.

> Making those connections between students' lives and the math they learn in the classroom is very important. Sometimes kids see math as something that belongs to school but when they leave the math classroom they just leave it all behind… By relating it to something in their life, then they go outside and make those connections "oh what I learned in math really relates to my every day life and I can use what I see outside and bring that back into the math classroom with my ideas and suggestions."…. It gives them a reason to learn. I have a lot of students who just come in and don't see school as being important or relevant to their life in the future. I have had students tell me in the fifth grade "well, I just have to make it till I'm 16 so I can drop out. Nobody in my family has ever graduated and I am dropping out"…. They might come from a situation where their parents didn't graduate from school, or a lot of times there is some kind of influence in their life that made them think school is not that important. So by using examples like that and showing them the importance it gives them a reason to be in school and a reason to learn. It's also more fun!

Laura believes that using traditional Native American culture when teaching mathematics to her Native students is an effective strategy since it is something they are familiar with and like to talk about. She thinks that it motivates students and also helps them to make connections between mathematics and real life.

> Yes, they can see it as important and it is true they are interested in it. Especially the kids who are Native American and do the Crow fair and are embedded in the culture, they see that as very relevant, very interesting…. I love the idea of using the culture. And my kids really love doing things that relate to math and things that go along with their culture. Relate it [math] back to their culture is important to them because I do believe if they see a purpose in what they are doing and if they can relate it to something that they already know they are more interested and they will make the connections…. I like how Ms. Sharp relates math to the coats that women wear and how that goes along with the tradition. The parka patterns, and the way she relates the shapes to nature… maybe when they go outside they will see something and say "oh there is the mountains, there are triangles!"

When I was observing, Laura made very little use of traditional Native American culture in her classroom. She did bring up many things related to modern life such as shopping sales, credit cards, cars and gas mileage. She calls it, “examples of what they might see every day.” During one of my observations, for example, while teaching students the relation between fractions and percentages, she talked about sale offers.

> When I talked about culture before, I think it is just as effective a lot of times to use examples of what they might see in every day life. I do a lot of examples of dividing up food and making it fair.... Food works really well but I use different things to get their minds thinking about math.... I did some things with shopping and finding good sales.... When you [the interviewer] were there, we talked about percentages off when shopping.... Anything where they see math as relevant in their everyday life I try to incorporate it with the units.

Laura would like to include more of the Native culture and art in her mathematics lessons but being non-Native she believes she is hindered from finding good resources. She believes a deep involvement in the culture is needed in order to know what will be appropriate cultural examples to use in her mathematics classroom. She believes she has not devoted enough of her time to get really involved with the community. However, she thinks she could overcome that lack of knowledge by using the help of some of the Native teachers and other people in the community, believing that they could help her to find good examples within the cultural context that might relate to certain mathematical concepts. She also mentioned getting help from parents and from the school administration.

> Unfortunately as much as I know about their culture, you have to be inside. You have to belong there or live the way they live in their culture to have access to the complete knowledge. Not just bringing in the coat, but understanding some significant things about what you are doing. I wish I would have done more of that…I didn't do as much as I could have, I feel If I would have done more I would have belonged.... I would need some help in finding the materials I guess. I would need parents to help find the dresses, or whatever we were working with cause I don't have a lot of the culture.... I think a lot has to do with the building, the staff, the

> principal. I know a lot of that has been tried and this is the hard part about bringing the culture in.... What is nice it is people like Ronda [a Native American teacher] that can bring it in because they are the right people. They can do it themselves or they know where to find it. The other thing is the student's parents. That is a good way to go to and have them participate. I have done that too and they have brought in the traditional dresses and let the girls try them on. That could be a good way, just use the parents.

Modeling and Demonstration

During her mathematics lessons, Laura is often at the overhead modeling problems and asking students to come up and share their solutions to some of the problems posed to the class. While modeling different problems, Laura normally solves them out loud allowing students to hear her thinking process. She also welcomes students' thoughts about how to proceed. She says: "I like the overhead, maybe too much. I am trying to show them how they can find the answer, modeling what they should be doing on their own once I let them work on their own."

Laura often models wrong and right examples.

> They are going to run into that right away and get frustrated and think that they did something wrong and so I try to model exactly all the situations that they could come across. We go through every one to see which ones work and which ones don't, I want to model what they will be working with on their own and for them to start off on their own and not get frustrated if it doesn't work.

Besides modeling to her students, Laura believes that sometimes it is a good strategy to let the students work in small groups to try to solve a problem on their own. That way, as they come up with their own ideas and strategies, students will model them to each other. Laura believes that having students modeling to each other is an effective strategy, even more so at times than teacher modeling.

> It is important for a student to hear what another student has to share. First of all they pay really close attention when one of their peers is talking. Kids speak in their own language and sometimes they can portray something better, come up with different ideas than the teacher would never think of or portray it in a way that makes sense to another kid more than an adult. I think they listen better to their peers too. Than they always do to their teacher, Hey let's do it the way Joe did it. That is cool, you know what I'm saying, it builds their confidence too.

While she believes that modeling is an effective strategy for teaching mathematics to her Native American students, Laura also believes that making students think on their own and come up with a strategy without the teacher modeling it first is in general an effective strategy since it helps students learn life skills and develop problem solving strategies. However, she feels that students need to have a clear understanding of the goal of the exercise.

> I think in Ms. Sharp's lesson, her idea of getting them to think on...how to make this perfect square.... I think that is a great idea because it is getting them to think outside the box, it is getting them to problem solve on their own. This is like a life skill. You might need to measure something someday and you don't have a tape measure, well maybe you can use a piece of string and take it over here and see if it is going to fit. You know it is getting them to use their brain in different ways so I think it is a great idea. It might be a little bit beyond… They might need a couple of more guiding questions to get them on the right track though.... I think there are times to just let them be creative but usually we have a goal and understand their goal, where they are supposed to go it is important to them.... I like giving them the blank piece of paper, but I always want to make sure that they understand what they are working for.... Once they see they can get this to work, they might have to go through some thinking here or some trial and error there but it's going to work. Then they get excited about it.

Joint Productive Activity

When Laura talks about group work, she talks about students sharing their own ideas and strategies with the group and trying to find new ones together. She also talks about students encouraging each other and relying on each other.

Laura did not at all like the video in which Ms. Sharp sits in the same circle as the students and works on her own pattern. Laura believes the teacher should not be working on her own task while students work on theirs, even if it is in the same project. She believes it is beneficial for the students to have the teacher close while they work but the teacher needs to be moving around, interacting, encouraging students and asking them key questions that will guide them in the right direction. She says it is a good opportunity to interact in a more personal level with a student.

> Her pattern is obviously beautiful… she worked very long and hard on that which makes me even more frustrated. Because in my mind a teacher should not be working on a perfect product you can be working a little bit on something but I never have time to do a perfect product when my kids are working because I am going around helping them, giving them ideas, asking them questions, encouraging them… I feel it would have been ok that she sat there and did the project, if she would have been interacting more with the students. I felt like she was in her own world working on her own project, perfecting her own thing.... I feel the kids get more exited and learn more if you are in there asking them questions and encouraging them....or even talking to the girls next to you about how their families are doing, making those connections with the students… Asking questions and helping them.... I felt like she should have been in there doing that instead of sitting back working on a perfect product…

Laura believes that group competition is a great strategy for her American Indian students. She start most of her mathematics lessons with a game called “I have-Who has?”, a chain drill involving addition, subtraction, multiplication and division skills. In the game students have cards with a number and instructions to modify it. The student chosen to begin the chain reads the card aloud, e.g., “I have nineteen, Who has that multiplied by three?” Then they wait for the next participant to read the only card that would correctly follow the progression. Play continues until all of the cards are read and the initial student is ready to read his card for the second time. In Laura’s classroom students aim to do it faster and beat

their time from the previous day. Laura likes the game because she believes it helps students develop skills needed to work with groups including cooperation and listening. She also likes the fact that students develop new strategies for arithmetic as well as improve their mental math which she thinks is an important life skill. Laura believes that using this type of group competition is an effective strategy because students are very motivated to play. Even though they answer individually, they are all competing together against time.

> The strategy [I have-Who has] works on their listening skills. They have to listen to each other and they have to cooperate, and mathematically they have to do a lot of mental math in order to figure out the strategy. I always tell them that mental math is a life skill, because they are not always going to have a calculator handy.... So I feel it is really important for them to be able to do some math in their head and to learn tricks. In the beginning, with the “I have-Who has” if it is taking time to get one, we always talk about strategies about different strategies. Maybe other kids in the classroom might have an idea into finding the answer, even a better idea than I might have. I think they see so much improvement in even 5 days in how fast they are solving the problem in their head that they gain confidence and they see math as fun. And I think they see "I have-Who has" as a game. If I don't do it one day they will complain.... they are begging me to do math! .... I think when you turn learning into a game or a competition it works.... They are competing with themselves but they are striving to do better. They are competing with a group and against their time from the day before.

Laura believes that making the game a group competition instead of an individual one is key to the effectiveness of the “I have-Who has” activity. With group competition, Laura says, students encourage each other and feel protected by the group even if they fail.

> I think kids in general don't want to embarrass themselves in front of the classroom and if it is an individual competition where this student is in the top twenty and this student is only two, I think that is a hard thing for a kid too...it kind of breaks down their self esteem and they might even decide they don't like math just because of the one game that doesn't make them feel good.... I like better group competition, they encourage each other and they get excited with each other.

Laura believes that when it comes to sharing your own work and ideas with the rest of the classroom, group work is always more effective. She believes that American Indian

students do not like to be exposed in front of the classroom and that they find comfort in a group. Laura believes it is important to make students feel that they are part of the group, so, even if they make mistakes, they feel is not as important since the group can learn from that.

> Ok, sharing individually that scares me, let alone them. They find comfort in a group. American Indians do not necessarily like to get up in front and share.... If they have to do that on their own, it is pretty scary and they shut down and then all they are thinking about is being scared and not about what you want to teach them.... But, as a group, they can come up with an idea to show the classroom. They are social. Kids love to work in groups and steal each others idea… give each others more ideas, and help each other out. They like to interact.... They feel the comfort of each other. Sometimes Native Americans seem not as confident and not as willing to come up in front of the peers by them selves at least.... I am thinking about kids I have had in my classroom and I had some Native Americans that were very willing to share but when I think about it as a whole the white kids have their hands up way faster than the Natives.... I try to make the atmosphere really caring about each other and more like a family so that even if they go up and their idea isn't great we can say "oh that's a different way of looking at it. Thanks for sharing."

Laura also believes that playing games is something deeply embedded in American Indian culture and that maybe that is why they respond so well to this type of approach.

> I think Native Americans really respond well to the competition.... They love to play basket ball and win so much… they are really into competition and games. I think in their culture there is a lot of game playing. And I think they respond well to that.... A lot of it has to do with the personality… but it does seem like the Native Americans like being with their friends and doing things in groups. It does seem like they have more confidence even in themselves when they are working with their friends… and they are more willing to branch out and explore the math concept that you are giving them if they have some support.

According to Laura there are times when individual work is more effective than group work. While she believes that group work is really effective when it comes to students developing new strategies and sharing with the classroom, she also believes that individual work is better for activities that require a deeper level of concentration from the student. For

similar reasons, she believes that smaller groups work better than bigger ones.

> When my kids are in their own desk, they focus better. When I put them in a circle they roll around, they mess around, they poke each other. Also smaller groups are easier for me to monitor individual students. I feel with bigger groups some kids get left out and are just sitting copying other people's work the whole time instead of actually forced to have a part in the learning.... If there is only two of them it is on their shoulders "we have to get this done!" versus a group of four or five "I can sit back, let them talk and later write down what they say…"

Other Strategies

One day, during an activity in which students had to represent different fractions by coloring fraction stripes (i.e., one-fourth green, two-fourths red, etc,) Laura gave them plastic colored tiles so they could use them to think the task through before they drew the colored fractions on the paper. She said she does that because the use of manipulatives helps students think things through. She believes it also helps students get over the anxiety of writing a final and permanent answer on paper. She also sees it as a great motivational tool since students love to play with tiles and other manipulatives.

> Sometimes, it is easier for them to think it over with tiles. When you color it is permanent, you can't change it, you can't fix it, you have to get a new sheet and start over. With the manipulatives you can change your mind; you can play around "oh, I thought that was right but now I realize it's not let's take these off!" It helps to get what you want before you copy it down. They also love it so it motivates them too.... Because of the hands on, they see it as playing, even if it is related to math and has a task. They are fun little tiles!

Laura believes that the use of manipulatives is an effective strategy for American Indian students. She thinks that while thinking a concept through, the use of their hands helps them make connections better than just working it through in their heads.

> I think American Indian students respond very well to manipulatives and that is why I use them a lot. I feel when they are moving their hands they make the connections better.... I feel like just telling them how to do it, or even showing them how to do

it, doesn't work as well as having them move and do it themselves.

Another strategy that Laura uses a lot in her classroom is choral response and repetition. She believes that choral response is an effective strategy because it helps students learn and memorize better. She thinks by using choral response, instead of asking individual students, you give everybody a chance to respond and repeat the concept and therefore a chance to learn it better.

> I use choral response. I think that is great because they all get to participate. I think kids learn by having to repeat things and having to say things out loud and hearing themselves say things. It also gets everybody in the classroom involved instead of just calling the one kid that always knows it… What about the other 15 in your classroom that haven't said anything all day? The one thing that you have to be careful with about choral response, is that some of the kids need more time to think, so you have to ask the question and tap or say something like "ok everybody!" and then they can say their answer together.... So [giving a cue] gives everybody a chance to learn and it holds the other ones accountable for learning as well.

Combined with the choral response and repetition, Laura uses a lot of word games and memory tricks to help students memorize mathematical rules. For example, to memorize the order of operations she uses the sentence "purple elephants make delicious alphabet soup." Her classroom is full of colorful posters, many of them displaying these type of sentences. Laura believes that students learn word tricks easily and never forget them which helps them when it comes to applying the mathematical rule later.

> Word tricks help them to remember…I like to use those because kids will even come back years later and say - I know the order of operations, purple elephants make delicious alphabet soup! -or different tricks they learn. They love that, because they can remember how to do things with it. I also do a lot of posters and they repeat things off the poster.... it is just memorizing the rules in a fun way for them. In math there are a lot of sequences that you just need to memorize and you need to know how to do. The posters help with it... and having things up visually for them to see is great.

But when I asked Laura to share with me the one strategy that she believes is most important when working with her American Indian students, the strategy she talked about had not yet been mentioned in our conversations. She believes that the most important strategy to use when teaching Native American students is to let them know that you care.

> I think the relationship thing is big because if they don't think you care it is almost as if they don't see a reason why they should have to listen to you.... Even if they see you kind of care about how well they do their math, they need to feel that you care about them outside of school, about how their mom is doing.... You need to build that social relationship. How do you do that? It is difficult because you feel so pressured with time and teaching them what they need… I have them do some journaling and every once in a while I'll call someone over to my desk and ask them how they are doing. I try to keep in pretty good contact with the parents.... if I see a change in their behavior at all I call their mom and see if there is something I need to know about and the students feel much better if they know you know, even if they don't want to tell you they want you to know and ask them about it… even as they are doing their work, or if they finish early, you can sit down and while help them out with their work ask them about their life at home, about how their family is doing and making those connections with them.... I probably feel, more than any other strategy, if the kids don't think you care, they will not respond to you in a way that is going to best help them learn…

Summary

Laura's philosophy of mathematics teaching and learning, as well as her knowledge and understanding of Native American culture shape her definition and implementation of the different teaching strategies. The implementation is also greatly influenced by the school structures and cultural background. Her beliefs are summarized in the following bullets:

- A strategy is effective if:
    - promotes students understanding, learning, memorization, engagement and development of thinking strategies;

- makes concepts relevant to students; and
- helps students to connect new concepts with things they know.

Contextualization:

- In her teaching, Laura builds a unit around a mathematical concept and imbeds familiar modern context as practical examples of the concept.
- The strategy is effective because it helps students to make connections with things they know, sparking their memory and interests while giving a purpose to mathematics and school.
- Feels limited in bringing traditional culture into her lessons due to her lack of knowledge of the Native American culture.

Modeling and Demonstration:

- In her classroom, Laura models both the procedure and the thinking process involved in solving simple tasks and procedures. She models both right and wrong examples.
- She does not believe that Native Americans need to see someone model the tasks they are to perform.
- The opposite of modeling is *Discovery.* Students perform a task with no guidance or previous modeling from the teacher.
- Discovery is very effective because it helps students to learn a valid skill and to develop problem solving strategies; but it is only effective if the students' goal is clear.

Joint Productive Activity:

- Laura frequently sets students to work in groups. She believes it is an effective strategy because students share ideas, get motivated, and find comfort in the group.
- Individual work is effective for tasks that require deeper levels of concentration.
- In her classroom Laura often does group competition in a way that resembles the research definition of joint productive activity, except for the teacher's involvement.
- Group games are an effective strategy because students encourage each other and feel protected by the group even if they fail.
- Individual competition is not effective because it intimidates students.
- For Laura, the teachers should never work in the same project with the students; she needs to be moving around, interacting, helping, and encouraging students.

Other Strategies:

- Letting students know that you care is the most effective teaching strategy for teaching Native American students.
- Other effective strategies include the use of manipulatives, choral response, and word games.

Teresa

Teresa teaches at Mountain High School, a school where 100% of the student population is American Indian. She lives in Mountain and is herself American Indian from

the same tribe as most of her students. She is very involved in the community and knows most of her students' families. English is Teresa's second language; at home and in her everyday life she uses her native language. In her classroom though, she teaches mostly in English and only uses Crow in one-to-one conversations with students.

Teresa's teaching is mostly procedural. She starts the lesson by lecturing at the board. She introduces new vocabulary, a formula, or a definition and then models several problems. Then she gives the students some exercises from the book to complete on their own. After that, Teresa watches the students for a while to see how they are doing. If they are on task and do not seem to have trouble solving the problems, she sits at her desk and works on grading. If she notices a student is struggling, she goes to his/her table and helps her/him individually. If several students are confused, she might complete another example in the board.

When Teresa talks about a teaching strategy being effective, she talks about students' excitement and motivation. She talks about students retaining the material and remembering it longer. Often, when asked about evidence or reasons why a strategy is effective, she quotes a teacher whom she had in college and who obviously had a great impact on her pedagogical beliefs and her teaching.

Contextualization

Teresa believes that relating mathematics concepts with something that students already know and are familiar with helps students to better retain and remember the new concept.

> Ms. Sharp was tying the culture back into learning these shapes, which is good. It is something these kids can identify with, it is part of their culture. And that way they could probably remember what these shapes are called. It is something that they see all the time but they don't think about it. But if they see it then they remember it because it is part of their culture.

When I observed Teresa in her classroom, she did not use any type of contextualization in her teaching. Her teaching was procedural and she always followed the book. She does believe, however, that connecting mathematics with students' lives is an effective strategy for teaching mathematics. She said she tries to do it often but she also mentioned that she tries to be practical and that if the book says that a chapter addresses the standards she follows the book and does not try to "reinvent the wheel".

> Yes, the use of culture in math is very relevant to my students.... For me when I am going through the math concepts that we need to go through, if the book shows that it addresses the standards from NCTM [National Council of Teachers of Mathematics], I trust the book. Then I don't try to reinvent the wheel, I just go ahead and try to teach what is in the book. But if I come to a part in the book where I can tie it to the culture I do.... with shapes in general.... Sometimes I talk about the beadwork or talk about the teepee with cones, and circles and angles.... In this lesson [slope of a line] I could have looked at the slope of teepee poles when they put in the teepee. Sometimes I ask the students to think about their own beadwork that they have. Sometimes I'll bring something in that they can look at.

One day Teresa had planned to introduce the slope of a line by going outside and letting the students build a human graph, where the students would be the plotted points. She was very excited about the activity and happy that I was going to be there to see how she contextualized her lesson. When the time came, she could not do it because the principal would not let her use the spray paint she had purchased and she could not find any chalk at school. When asked about obstacles to the use of culture or any other context in her teaching Teresa talks about practicality, time, comfort zone, and routine. She also takes part of the blame, saying that she needs to put in more effort and find the time and alternate ways to

incorporate more culture in her mathematics lessons.

> I do as much as I can I do.... When we were doing the slope I wanted to use an activity they showed us at [a workshop], where you put a grid in the parking lot outside and then the students become like human plots. Then you can work with the slope. I wanted to do it but the principal would not let me paint on there…He said to use chalk and I couldn't find any chalk so I let it go.... I have to be more prepared to do that, find it ahead of time. I have to buy some of that sidewalk chalk ahead of time, two weeks before when I go to [the city, 50 miles away].... because we don't sell it at the store downtown. We have limited resources and you have to just plan that much more ahead but, you know, when you are going so out of time… And most of the time it is lack of preparation I think. With this one I felt like I could have done it if I was prepared but I wasn't prepared enough to do it. Sometimes I am so busy and I assume that something is going to go ok and when you get to it then.... I just need to put more thought into how to bring the culture into the classroom. Find those opportunities and just do them.... I have the resources like the beadwork that we have at home… I can just easily bring them. I just don't… You get into a routine and then forget. It is easier to teach this way, you feel more comfortable, you don't have to prepare so much…

Teresa's understanding of contextualization, as represented in the human-plot activity, seems to be closer to a multiple representations and hands-on activity.

Teresa believes that a good way to bring culture to the classroom is by using her native language in her teaching. In her classroom though, she mostly teaches in English. Except for small conversations with individual students, she never spoke her native language while I was observing her classroom. Teresa says she uses Crow sometimes when she needs to explain the meaning of a concept that students do not seem to understand in English. Most of her students do not speak their native language but they all understand it. Teresa said that Crow language is sometimes simpler and more direct than English and therefore sometimes it is easier to explain things. When I asked her why she does not teach in Crow, she said it had never occurred to her. Also she said that she normally teaches in English because that is the way she learned mathematics and therefore there is certain vocabulary she has never

learned in Crow.

> Well, you can bring culture with language like when we are going through a concept sometimes if I have to use the language when I know they don't understand… I use it and sometimes that makes a difference. Right now a lot of our students don't speak Crow... but they all understand it. If I am speaking Crow they understand me. So if they have trouble understanding something, I will say it in Crow and then I know that they understand. I think sometime they understand better math when I speak in Crow.... If something is said in Crow then it drives right to the point.... I just never thought about teaching the whole thing in Crow. I don't think I can if I wanted to. I would have to be very fluent in the Crow language. I speak Crow, Crow is my first language.... but still with these math concepts and stuff, the words are… you have to really think about it to translate it into Crow on some of them. But certain things I can describe better it in Crow.

Modeling and Demonstration

On one of the clips from Ms. Sharp's video (Lipka et al., 2005), the teacher asks students to make a square out of black construction paper without too much success until she decides to model how to do the first fold. Once she starts modeling the students are all observing and on task. After watching the clip Teresa said:

> I think the kids are excited about what they are going to be making. When she is giving the paper to them they are all eager to start but then they don't know what to do. Then she shows them a sample square and they still don't really know how to get there. They have probably never done one before. So all they have is this piece of paper. She is asking them to do a square and I think she is trying to let them discover it on their own. She is leading them there but they still don't know what to do. The kids just know that they need to get to the shape but I don't know if they have enough instructions to get there.... Then she starts the folding. She is leading them to do it, she is modeling it for them by showing them an example of what to do, paper folding and stuff… they are all paying attention and then they get right away and try to do it. She shows them and ... they finally start moving they all get on task and they look at each other, and they learn from each other. Before they did not have enough information to start, and now they have.

The previous quote describes quite well what Teresa thinks about modeling. She believes it is an effective strategy. She believes students need to see how things are done before they

can try to do it themselves. When she talks about modeling, Teresa mostly refers to modeling the procedure.

> I think by giving them instructions first, she [MS. Sharp] was just trying to make them think to make them discover the concept. Sometimes I do that and sometimes I give them the problem step by step. For example when it comes to solving equations or when they are learning the process of operations, I tell them the process and then they have to apply it. But I model the problem for them; I do a problem for them so they can see how to do it.

When discussing with Teresa why modeling works with her Native American students, she often refers to a professor in college. It seems she deeply believes that modeling works better, and it also appears that she believes this because that is what she learned in college.

> I think it's me, what I think and what I learned from my instructors. When I was going to college I remember one of my instructors telling me that if you want them to do something, you have to show them what to do. “Give them a model if you want them to do it a certain way, show them and then let them do it. If you want them to do something, model it for them, and then let them do it.” And I also do it because usually it works!

Despite her preference for modeling, Teresa believes some students might benefit from discovering things on their own without any guidance from the teacher, a strategy she called discovery. She thinks discovery could work for her advanced students but she also believes that the other students might get lost and give up. The great span in mathematics skills that her students bring to her classroom makes it, according to Teresa, hard to use discovery in her mathematics teaching.

> Most of the times, I model it for them. A little bit of discovery, yeah, when they are first starting new concepts. But most of the time I model it for them. But I know that also some students remember it longer if they discover it themselves. I guess you need to look for different opportunities. But also with my students, they all come in with such varied skills... Some have really good skills some have really low skills and if I ask them to do the discovery on everything, I think that I would lose some

> of the students if I do it all the time. Yes it will engage the students that have high skills and I know they will bring some of the other ones along but a lot of the students they get frustrated and say "I don't want to do it anymore." They need guidance; they need to be modeled.

On one of the days I was observing her classroom, after lecturing, Teresa asked her students if they were ready to do the problems from the book. They said yes, but after several minutes nobody was working. Teresa called them back and modeled the first problem. After that students started working.

> I was trying to get them started on their assignment.... I don't know, they were off task or were not getting started. Usually once I can get them to start on a problem then they get going. It is similar to what happened to Mrs. Sharp, most of the times they need to see one in order to start. Like my professor said "you have to show them how to get there."

Joint Productive Activity

In Teresa's classroom students are mostly sitting at individual desks with the chair attached to a desktop. In one corner of the room there is a table that seats four students. When students work on problems in her class, only a few work in pairs. Most of them work individually and some of these work alone but compare their final results with classmates. Teresa does not encourage or discourage group work in her classroom. When Teresa talks about group work, she does not talk about activities designed and directed towards students working in groups to solve certain problems or come up with a common product. She does not talk either about the idea of joint productive activity in which experts and novices engage in dialogue while working together for a common product or goal. When Teresa talks about group work, she talks about students sitting together while they work on the problems assigned by her in the classroom. She talks about students helping each other, learning from

each others' work. But while she believes that students can learn a lot by helping each other, she also believes that some students feel more comfortable working on their own and that teachers should let students choose whether they want to sit with other students or not, respecting their personal space.

> I think when students work together they look at each other, and then they kind of learn from each other… sometimes I do ask them to work together but I don't do that a lot, I kind of leave it to them. Sometimes with these students it seem like they really don't want to [work in groups]. They would rather have their own space a lot of times.

Teresa also believes her classroom furniture and arrangement, with small individual desktops attached to the chairs, do not favor group work. She wishes she had big tables where groups of six or eight students could sit around them and work and where she might sit with them and help them when needed. When asked about why she would not rearrange the furniture in her classroom to have, for example, four desktops grouped together, she answered that she would be imposing on students who might prefer their own space to such an arrangement.

> To me with the way our classroom is set up, with our desks and stuff I just really can't sit down with them to do it. [If I could choose my setting] I would use tables like this [we were seated at a big table that could seat from six to eight students], big ones. I would use tables and chairs instead of desks. Bigger tables would be better because they would be sitting together and they could work together. And if I need to I would be able to sit in on each table.

Regarding big groups versus small groups, Teresa believes that, in general, her students feel more comfortable sharing ideas with small groups (like those sitting around a table) than in front of big ones. She believes that is the reason why her students often do not answer the questions she asks in the classroom. They do not like to be exposed in front of everybody. She said: "I think it is easier for them to share ideas if it is just two people, but

if it is a whole group I think it is hard for them to do that. They don't like to be exposed on their own. It is safer in a small group than in big ones."

If Teresa notices a student is struggling, she goes to his/her desk and helps her/him individually. During my observations, she helped students solve some of the book examples either individually or by addressing the whole group, but she never worked together with them to solve a problem or come up with a common product. Normally, while students worked on book problems, Trivian sat at her desk grading.

> By making one pattern herself [Ms. Sharp], sitting there, the students can observe her and get an idea of their own. When we do algebra tiles, I do an example and then I will ask them to do it on their own too. On one of the problems, I'll do it but I won't let them see how I did it. They will do theirs and then I'll show mine, I'll put it up on the projector and then they will look and compare it with theirs.... So really they don't see what I am doing so they are not really observing of how I am doing it, they just know I'm working on it and they work on their own separately.... So I guess is different, and no, I don't sit with them and do it.... It seems though like a lot of times I am in my desk. We go over everything and if I see they are struggling, I usually go over and help them one by one, individually. But if they are working and on task I just do as much grading as I can. I always need the time for grading, it seems to pile up, it's like never ending…

Other Strategies

Teresa's teaching is mostly procedural. She lectures at the board, models several problems, then gives the students some exercises from the book to work on their own. She follows the book and goes through everything step by step. Her notes on the board are very procedural and very clear. Most of the students copy her clean notes in the notebook she asks them to keep with all their mathematical work. To her, it is important they have a manual to follow and go back to when needed.

> I guess I feel that is the best way with these kids. Right now is how I feel. You know I have them keep a note book of all the stuff we go over. A couple of my students

> went to college and afterwards they told me that they still had their notebooks and when they went to college they used that to help them through. So then I thought that maybe it is a good way to do this.

Teresa believes that one of the most important teaching strategies she uses with her students is treating them with respect. She believes that if you respect them, the students will respect you back. She thinks many teachers disregard this matter and therefore get in the way of their students' learning.

> I think that what works for me with teaching is if I have the student's respect I can get more out of them. I treat them, and talk to them in a good way. I try not to talk down to them. I try to talk to them like a person. I don't degrade them.... Just talk to them in a respectful manner. If you respect them they will respect you back.... Some of the other teachers send the students to the office with every little thing. Like Robert, who is usually late, if he is tardy they will send him to the office and he just sits there, doing nothing, no production, no nothing. But I let him in, I mark him tardy and I put it in the computer so the office knows he is tardy but he is in classroom. I keep him there because I know he is going to work. If I am not on his case, yelling at him… he knows that he needs to get to classroom and get his work done and I give him that space because I know his background so sometimes he just needs a little bit of time to think… and he is usually tardy but he is there.... And some teachers if they don't bring a pencil, they say "go to the office" and they just mess up because they don't have a pencil… and that same instructor [in college] told me "if they don't have a pencil give them a pencil!. For some reason they don't have a pencil, that is not the issue, the issue is they just need one. Give them a pencil so they can work." He also told me that "if your students want extra credit they want to work, let them work." Some teachers say "no, you are not going to do extra credit at all". That is an opportunity! Maybe that is going to get them to learn something that they missed out on. Take that opportunity and let them do it.... If they ask for it, give it to them!

Teresa is from the same area and tribe as most of her students. She is very involved in the community and knows most of her students' families. She believes this is very important. According to Teresa, knowing your students' background allows you to better help your students learning. She said: "Yes, I am from the same area, I know their background and I know the families. I think teachers that are not from the area can get to

know their students' backgrounds by just working with the teachers around them. I think is important."

Summary

Teresa's understanding and implementation of the different strategies as well as her beliefs regarding the efficacy of the strategies with Native American students in mathematics are clearly influenced, among other things, by the structure of the school (time, resources, and curriculum), and her previous personal and professional experiences. The great influence that her former professor in college has on her beliefs is a good example of how her previous experiences are shaping her use and understanding of the strategies. Teresa's understanding of mathematics teaching and learning, combined with the incorporated curriculum of the school, seems to also have an influence on her understanding and use of modeling.

The following bullets capsulize Teresa's main beliefs regarding effective teaching strategies for Native Americans in mathematics:

- A strategy is effective if:
    - promotes students excitement and motivation;
    - helps students remember concepts better and for a longer time; and
    - she learned it from a professor in college.

Contextualization:

- Teresa try to contextualize in her classroom but no evidence of her use or exact definition of contextualization was found in this study.
- Connecting mathematics with students' lives is effective because it makes mathematics relevant to students and promotes learning, retention, student

excitement, and motivation.

- Feels limited when contextualizing because it requires a lot previous preparation, it is time consuming, and it requires the teacher to get out of her comfort zone.

Modeling and Demonstration:

- Teresa models procedures and solves problems step by step.
- Modeling is an effective strategy because:
    - Native Americans need to see a task before they attempt to do it; and
    - a professor in college told her “if you want them to do something, model it for them, and then let them do it.”

Joint Productive Activity:

- Teresa’s definition of group work involves students working together solving book assignments.
- In her classroom, students work individually for the most part.
- She does not promote or discourage group work.
- Group work is effective because students can help and learn from each other.
- She believes some students prefer to work alone.
- Sees her classroom’s furniture arrangement as a limitation for students working together.

Other Strategies:

- Giving students an opportunity to keep a clean notebook as a manual for all the procedures and formulas is an effective strategy.

- For Teresa, the most important and effective teaching strategy of all is to treat students with respect so they will respect you.

Julia

Julia teaches mathematics at Mountain High School, and 100% of her students are American Indian. Julia is white. She lives in Mountain during the week and drives several hours to go back home to a different town for the weekends. Julia is a veteran teacher who is close to retirement and has been teaching in Mountain for the last 15 years. Before that, Julia had taught in different all-White schools in mostly rural and economically depressed areas of the country.

At the beginning of the study Julia said she does not see any obvious differences between the way Native and non-Native students learn or between the strategies that are more effective for teaching mathematics to either of the two groups. However, during all of our conversations Julia talked about strategies that she considered effective for her students in Mountain who, as mentioned before, are 100% Native American.

When Julia talks about a teaching strategy being effective she refers to student engagement and to students being focused and on task. She also talks about the teaching being meaningful to the students and about students remembering what they learn.

Contextualization

Julia believes that integrating culture, language and mathematics is a valuable strategy for her American Indian students. She believes that if you relate the content with something meaningful to your students, they will be more eager to learn and will remember

better. Julia always tries to use real examples, manipulatives and real objects.

> To me, you must have something to see… you could use a picture from the book or draw a sketch on the board but… it has to be something they are more familiar with, something you can take a hold of. It seems more meaningful if you actually have an object that relates to the math in some way. I think it is important to relate [math concepts] to something that is real, what is in the book what is on the board is not real I don't think..... I use real objects to try to make it real, something they can absolutely relate to so it helps them remember.

Julia's classroom is full of boxes, drawings, and geometric models made by students. Among them, for example, there are some three-dimensional prisms that her students built using origami techniques that she often uses to address different geometrical concepts. It is very common to see Julia and her students with different objects in their hands as they discuss different mathematical problems. One day she brought a variety of food packages for students to calculate the different volumes. Julia believes that using such real objects is more effective than using the more traditional three-dimensional plastic manipulatives that are often used in mathematics classrooms, including hers. According to Julia, real objects relate more to students' lives which helps her make the studying of mathematics more relevant and meaningful to them.

> The yellow figures that you buy out of the catalog are not part of everybody's day… but the things you pull off the pantry shelf relate to things that they deal with every day. It is reality "these are the things that are in my life." I guess it helps them to see that what we are studying has some application in their life. It might even be more meaningful if you went out there and measured the sidewalk and calculated how much cement it took to build the sidewalk or what if we wanted to do basketball courts out here.... When you take actual objects it helps you remember so if sometime in the future you want to actually calculate the volume of something you may remember "Oh yeah! I did that once."

Not being Native American, Julia has had problems in the past integrating the traditional Native culture of her students in the classroom. According to her, some students

do not feel it is appropriate for a non-Native to be "teaching them" about their own culture.

> I have tried to use Crow designs in geometry a number of times, sometime successfully and more often it didn't seem to go well and maybe it is because I am not Crow. One time I and the art teacher did a joint math art classroom. Even though she had very strong Crow roots, she herself was not Crow, she had lived there 40 years and was married to a Crow. But we were told by one student "I am going to drop your classroom because I can learn all this from my grandmother and she knows what she is talking about".... and that isn't always the case but it has happened.

She believes you can get around that by using a broader meaning of culture, including the modern culture of the students, what she calls the "now culture."

> I don't think it has to be just the native culture, I think it is their [the students'] world. There is the native art but a lot of their culture is a broader culture. They are not separated, that part of the culture [the traditional art] is somewhat of an oddity to them, a history to them.... You need to relate it [the mathematics] to their now culture.

When observing Julia's classroom I saw many examples of her use of the "now culture." Once she started the classroom by telling the students "Yesterday I was walking in Mountain on my regular walk and I was on First Street and I wanted to go from this point to this point [she actually draw a map and named places that were real locations in the town] and I was thinking, if I had some free time and wanted to get some exercise, which of the two paths would I take? And what if I was in a hurry?" Examples like that are very common in her classroom.

> Yes, whatever you can relate it [the math] to. I take pictures of buildings in the area and bring them and say "here is a picture of the truss of the house. If they are building this house 30 feet wide and they got this height, 12 feet, how long do they have to cut these rafters?" So if you are doing Pythagoras, there you are!

Julia also suggests bringing in native art without trying to teach the students what it is but as an example of geometric patterns.

> I have been careful not to teach it as me teaching them anything about their own culture but to use their designs to teach the mathematical concept. You know, “here are some pictures of Crow saddle bags or blanket strips, let's look at them and see how it relates to the geometry that we are working on.”

She has found that some students get excited about the cultural part of the activity but they do not want to do the math.

> Some of them are interested. I have had them take a design and I say “Now I want you to make a design that contains these elements out of this one and make it fit this particular size object”, so I wanted to do proportions. And I have had a hard time keeping them, they love to do the design but they don't want to do the math, the proportion “oh, why can't I just draw it?” I think that when they do actual designs, they don't do them mathematically, so they can do the design and they don't see the need to mathematically calculate anything.

Time is another big obstacle that Julia faces in order to introduce students’ culture into the mathematics classroom the way she would like to.

> And when I have tried taking them outside to do some activity like that [the one about going out and measuring the sidewalk to calculate how much cement is needed to build a basketball court], I think it is useful but our time constraint is so limited. Time to get out there, time to focus, time to do it… and it seems like the classroom period is gone before you have accomplished your project.

Modeling and Demonstration

On the clip from Ms. Sharp’s video (Lipka et al., 2005), the teacher asks students to make a square out of black construction paper without too much success since the students immediately start playing off task. The teacher lets them play for a while and at one point she decides to model how to do the first fold. Right after she starts modeling the students are all observing and on task.

> Once she [Ms. Sharp] has given them the idea of folding, once he has modeled the first step, I see one or two start to follow her. They are all really watching her. This one little girl over here she starts almost right away and pretty soon they are all into folding.... They really didn't know where to begin and once she has given them a

starting point they get the idea “ah! Here is how we can start.”

Julia has seen the same thing happening with her students. She thinks that many of her students are also not eager to start trying to do something unless they have some guidance. She mentioned, as an example, one of the scenes I videotaped during one of her classes.

> When we have the two girls here [referring to one of the lessons in her own videos], I want that student to think about how to find the area of this hexagon but she has no idea and she is not going to sit there and struggle much longer.... You have to give her somewhere to start, so you start telling her “why don't you divide it into some figures you know how to do?” And so it is like with the students in the video, until she started folding that paper, they didn't know where to begin.... Yeah, it’s the same with my students, if you give them a starting point, if you model the first steps, and give them some guiding questions, then it might help them to get started.

At first, Julia thought the strategy of letting the students think/struggle was not very effective for Ms. Sharp since her students were all distracted, but as the lesson progresses she changes her mind, finding a purpose for that strategy: give them time to realize they do not know how to do it.

> As the lesson continues I think it wasn't totally a waste of time giving them the free time to try to think it through and realize” I don't really know what to do.” I think that wait time to give them time to try and think a problem through, as long as it doesn't go too long that they completely lose where you are going. That is probably good.

In fact, Julia would like to give students time to think on their own and even to struggle more often. She believes that developing the capacity of coming up with their own ideas without any guidance from the teacher or anybody else is a valuable skill that students need. However, she says, she has not yet managed to make it an effective strategy since her students tend to give up fast when they don’t know what to do. She has noticed they need to have some guidance and modeling from the teacher before they attempt to solve the problem at hand. Julia believes that part of the reason is that students are, for the most part,

used to somebody doing it for them if they wait long enough. However, she keeps providing opportunities to let her students think and figure problems out without too much direction because she believes is a very useful skill students need to develop.

> I do it periodically because I think they need to develop that but I have not yet been successful.... I don't know how to engage them in thinking because it seems as soon as they don't know what to do, 90% of them or in some classes 100% of them give up, and it is like they have learned "if I just wait long enough the teacher will tell me." Whether it is a complete project like this or something you have never done before or just if the problem looks hard "I just don't want to do it, so I will play dumb and eventually they will tell me the answer." I think if we did more of it at the level in the video [1st grade] by the time they got to my level they would be more willing to struggle.... If you wait two minutes and they can't figure it out they are gone. And I don't know how you break that....You want them to think, you want them to come up with something and maybe if you give them enough time maybe they will start actually thinking the problem through.

Time, once more, seems to be a limitation to what Julia would like to do in her classroom:

> That is something I have trouble with, letting them struggle when they don't have any idea where to go… I guess because I want to get to the end result and it seems like we are just wasting time.... And you've got such little time, you have this short period of time and you have all this material that needs to be mastered. And you are sitting there saying "I am wasting ten minutes while some of them have given up and a few are still struggling" Where is the balance?

Joint Productive Activity

Julia's classroom is set so that there are three groups of four tables each. In each group the tables are facing each other, forming a bigger table that can seat four students. Normally there are two or three students per grouped table. Group work happens in a very natural manner in Julia's classroom. As soon as she asks students to work on something, they start asking each other questions or debating about how to approach a problem with the other members of their group. The tasks are the same for everybody and they are meant to be

solved individually, but the students all use their groups to exchange ideas and come up with strategies. Then all of them write answers in their own notebooks, solve their own puzzle, etc…

During my observations, the desks were always arranged in groups as if at a table. But Julia believes that there are certain times when it is necessary to seat students individually. She sets students to work individually when she runs individual evaluations or when discipline problems exist.

> I alternate; sometimes I have them in groups, sometimes I separate them.... I think it is important that they be seated in such a way that they can communicate with each other, but it can get out of hand and they don't communicate on the subject at hand.

However, she said that letting her students work in groups is definitely a more effective strategy since she believes that students working together and talking about mathematics is what makes it meaningful and also helps the thinking process.

> Math or any subject is meaningful only if you can talk about it to somebody else. You have to get it outside of your own mind.... To hear somebody else's ideas help you with yours. If you are stuck on something somebody else in your group can have an idea. And no one individually understands the problem until they put it together and each puts in their part.

While Julia believes that group work is effective for most of her students, she never forces them to do so. Most of her students prefer to work in groups and, as mentioned above, do it in a very natural manner. Some other students, though, prefer to work alone, and Julia believes she needs to respect that. Another factor that Julia talked about were social relations in the high school and the need to be careful when putting students together who might have personal confrontations and refuse to work together.

> It varies from individual to individual. There are some students who never like to be in a group and I have quit trying to force that group work if a student just isn't comfortable with it. And in this particular classroom there is one girl who I have in a different section of geometry earlier, and in that other section she was very much withdrawn and did not work with anybody. But when I put her in this group, she had some people she could relate to so I think it is important to look at each individual.

One of the days that I was observing Julia classroom, only two students, both females, came to class. They sat down at separate tables and worked individually on their projects for the whole hour. I asked Julia what the reason was for not seating them together or asking them to help each other. She talked about their difference in mathematical skills and about their social relationships.

> One girl is very strong in math and the other is very weak and if you put them together the weak girl would not have struggled and figured out how to do it. They could help each other, yes, but I think when you have a very strong student sometimes that student does all the work and the weak ones rely on the strong. If they would have had a little more similar skills I probably would have put them together but these not only are the extreme top and bottom but they don't get along socially.

Julia believes that the teacher sitting with her students and working on the same project is effective with her students when they are doing a hands-on activity (like origami), but for other type of activities of a more abstract nature (like solving quadratic equations), she thinks it is more effective to walk around and be available to her students in case they need help. She does both. Her choice of strategy depends on the level of difficulty of the task on hand.

> It depends upon the type of thing. If it is a hands-on project where I would expect they should be able to figure it out, then I think it is more effective for me to kind of remove myself and be doing my own thing. But if it is something that is really new and I would expect they would have a lot of questions then it might be more effective for me to circulate.... If it is a hands-on project I think they would do better if I am seated. But if I am teaching a lesson on solving quadratic equations or a word problem I may be more inclined to wander around because they are more likely to

ask for my help than if I sat down and worked the set of problems myself.

In reference to the lesson where she gave her two students different food packages and asked them to find their volumes, I asked Julia what would have happened if she would have sat down with them to try to figure out some volumes.

> Often if I sit down with them in that case they rely on me and they will start to do something and they will want affirmation that anything they do is correct before they will move on, especially the weak student. Donna will not try something if I was standing there. If I was sitting there, with her, she would not try… She would wait for my input. I think she would be afraid she was going to do something wrong.

Other Strategies

In addition to making mathematics more relevant to her students, Julia sees another benefit to the use of real objects. She talks about the importance of using manipulatives and how it is important to stimulate what she calls "all the senses" to appeal to all different type of learners.

> I think the hands-on engagement is relevant at whatever level you are teaching. And it is certainly relevant to my high school students. So if they have something they can take a hold of, whether it is cultural or not, I think it engages them more.... Isn't that the way we all learn better? If you are sitting there, listening to somebody talk, pretty soon your mind wanders. But if you have to do something with it, it has to help you stay focused. I think you have to use all of your senses to learn. Also, different students learn better by different methods so if you have all of those senses hopefully you find the one that each student can relate to.

As Ms. Sharp does in the video, Julia also finds the need to repeat mathematical terms over and over during the lesson. She does not ask students to repeat the words in a choral response mode, but she does repeat the vocabulary often during the lesson. She thinks some of her students start high school lacking mathematical vocabulary. She believes that repeating the vocabulary often, using the same word in different situations, and hanging

posters on the wall with terms and concepts are valuable strategies to improve students' vocabulary in mathematics.

> She [Ms. Sharp] is trying to explain these words and concepts... and with this level you have to keep going over and over the same thing.... It is not a whole lot different in mine.... I think they have to be used repeatedly because… I feel, and maybe it is not true, that a lot of my students have arrived there without having had this kindergarten experience.... But through those grades of learning if you haven't gotten that vocabulary then it still requires that repetition. And you may not sit in classroom and in chorus repeat -this is a square, this is a rectangle- right? But they have to be done and said over and over and used in various ways before they begin to stick. And they need to be up there on the wall on the board for awhile. So if they make a poster of these new concepts you put them up and keep them for awhile. So I think the vocabulary it is where my geometry students struggle because there is so much vocabulary to geometry.

Regarding the use of the students' native language in the classroom, Julia does not believe that speaking Crow would make a big difference in teaching her students mathematics since, according to her, most of them do not speak Crow. She wonders though, since many of her students understand Crow, if knowing the language would make it easier sometimes to explain a concept due to the structure of the language.

> I do not think it would be beneficial for my students in math [if I spoke Crow], because I don't think there are very many of them who are at all fluent in Crow. I think some of them can understand a certain part of a Crow conversation. They never carry on a conversation between themselves in Crow. I don't think at my level it would benefit them to have a Crow speaker.... Maybe because of the construction of the language she [a Crow teacher who is fluent in Crow] is able to explain things better to them. Even though they are not speaking it in Crow, I think some language construction might be different and that might make a difference.

Summary

Julia's previous personal and professional experiences, her cultural background, and the structure of her school shape her understanding, validation and implementation of the different teaching strategies. The following bullets capsulize the main ideas of Julia's

summary of beliefs:

- A strategy is effective if :
    - students are engaged, focused and on task;
    - teaching is meaningful; and
    - helps students better remember what they learn.

Contextualization:

- Julia brings students' culture to her classroom in two ways:
    - builds a unit around a mathematical concept imbedding real contexts into it; and
    - builds a unit around a real context imbedding the mathematical concept into it.
- She uses modern culture more often that traditional because:
    - students identify better with the "now culture" ; and
    - she has found a resistance from the students towards a White teacher talking about their native culture.
- Contextualization is an effective strategy because students are more eager to learn and remember the mathematics better.
- She finds it challenging to get students to draw the mathematics out of the context.

Modeling and Demonstration:

- In her classroom, Julia uses verbal and visual explanations to model both the procedure and the thinking process involved in simple tasks and procedures

- Modeling is an effective strategy because her students are not eager to attempt solving a problem without any guidance or previous modeling from the teacher.
- She keeps trying to implement *discovery* in her classroom but it is often not effective because students struggle and give up.

Joint Productive Activity:

- Julia's students sit in groups of three to four students and work in groups often and in a natural manner.
- It is an effective strategy because talking mathematics with another person makes it meaningful and helps the thinking process.
- Students' social relations and different levels of skills limit the implementation of group work.
- The teacher working on the same task as the students is only effective for hands-on activities.
- Individual work is effective for individual evaluations and when discipline problems exist.

Other Strategies:

- The use of manipulatives stimulates all the students "senses" and help their thinking and learning.
- She has posters displaying the important vocabulary, and uses new vocabulary often and in different contexts to compensate for students' poor vocabulary.
- She believes that using the student's native language would probably not be an effective teaching strategy for her Native students in mathematics.

Question 2

What concordances and discordances exist between the beliefs of teachers who work with American Indian students in mathematics and research literature on effective teaching practices for American Indians in mathematics?

The answer to Question #1 summarizes the beliefs of the four teachers regarding effective teaching strategies for Native American students in mathematics. To answer Question 2, a description of the apparent concordances and discordances that have emerged in this study when comparing teachers' beliefs and research literature regarding effective teaching strategies for Native American students in mathematics will be presented. An explanation of the possible rationale behind those discordances and concordances will begin to emerge in this section and will continue in Chapter 5.

Contextualization

In contextualized instruction, the teacher connects educational content to students' personal lives and the values and traditions of the local community, and provides instructions in familiar, everyday contexts, about which students have previous knowledge, enabling students to make sense of instruction and to construct new knowledge accordingly (Tharp, 1997; Trumbull et al., 2002). Researchers agree that contextualization of the mathematical content has been proven to be effective for American Indian students in mathematics (Hilberg et al., 2002; Pewewardy, Lipka et al., 2005a). However, today, in most schools, mathematics as taught is not contextualized in the way that links to Indian students' experiences at home and in their community, especially for those living and studying on

reservations (Pewewardy, 2002).

When the four teachers involved in the study speak about connecting mathematics with their Native students' culture, they all seem to agree that it is an effective strategy for their Native American students in mathematics. They believe it motivates students as well as helps them to better learn and retain new mathematical concepts. According to their comments, they all try to contextualize mathematics in their classrooms. Despite all the agreement, the four teachers' understanding of "connecting mathematics and students' culture" does not seem to be always the same and does not always match the definition given by research. Ronda and Laura, for instance, both embed small pieces of students' lives into the mathematical units they are teaching but Ronda usually does this to introduce a topic, and Laura uses real contexts as practical examples of the mathematical concept she is teaching. The understanding that the teachers have of the strategy, as well as its translation into classroom practice, seems to be idiosyncratic to each teacher and appears to be shaped by different "lenses."

Ronda, for example, has an understanding of contextualization in which the teacher builds a lesson around a mathematical concept, bringing a familiar context to the classroom and using it to introduce the new mathematical concept. Once the concept is introduced, the lesson continues and the context is not used again. From the data collected in this study, a few different lenses seem to shape Ronda's understanding and implementation of contextualization. On the one hand, her cultural background and previous personal and professional experiences seem to be the basis for her appreciation for the value of contextualization. Ronda is Native American and has grown up learning at home by

contextualizing new knowledge with nature. She believes that this has always been the traditional way of learning for American Indians. She also believes that this is still an effective strategy today in her experiences with her students. In this, she agrees with research that claims that American Indian students' have an intuitive and experience-based mathematical knowledge that is not usually included in schools (Pewewardy, 2002).

On the other hand, the structures of the school (the incorporated curriculum, the Accelerated Math program, and the limited time devoted to mathematics) prevent Ronda from using a more complex version of contextualization, closer to the one given by the research, in which the context leads the unit and the mathematical concepts are imbedded into it. Ronda believes contextualization, as presented by research, is probably more effective than the way she implements the strategy in her classroom but the time constraints imposed by the school structures prevents her from doing so.

Culturally contextualized curricula connect the student with his or her heritage and bridge the gap between his or her world on the reservation, community and the different world that may often exist in the school setting (Barta et al., 2001). According to the research, building such a bridge requires a degree of cultural literacy (Smith, 1991 as cited in Pewewardy & Hammer, 2003). Some research has shown that where the students and teachers share the same culture, learning is enhanced (McCarty & Watahomigie, 1999; Erickson & Mohatt, 1982). This relates to Laura's concern about her limitations in the use of contextualization in her classroom due to the fact that she is not Native American. She does not feel she has enough knowledge of the Native traditions which limits her use of the Native culture as a context in her mathematics classroom. She overcomes that limitation by

using the more "modern culture" of her students as a context in her classroom. Laura agrees with the research when it says that when teachers are not familiar with their Native students' culture, help can be sought from leaders in the community, or experts in Indian education (Davidson, 2002). Laura also points out the students' parents as a great source.

Julia is yet a different case. She brings culture and real contexts to the classroom in two different ways: sometimes a real context leads the activity using mathematics as a tool to solve a real problem; on other occasions the context is just a prompt to make the predominantly abstract mathematical activity more appealing to the students. While she believes that the first way of implementing contextualization, similar to the research-based definition, should be more effective with her Native students, she also expresses her frustration on how challenging is to get her high school students to draw the mathematics out of the context. Therefore, even though her theoretical understanding of contextualization agrees with the one given by the research (the context is the essential center from which the mathematical contents emerge), her previous experiences implementing the strategy have often made her to modify its implementation to a simpler strategy in which the mathematical content is the center of the unit and the context is imbedded to make it more interesting.

Julia also uses more "modern-culture" than traditional but she does it for a different reason than Laura. Julia has been teaching in the same school for over 15 years and is quite familiar with certain parts of the culture. She believes though that her students are mostly separated from the traditional culture and see it as almost an "oddity", a "history" to them. She believes it is more effective to use a "broader" meaning of culture to contextualize mathematics, what she calls the "now culture." This contradicts Davidson (2002) who in his

study in the Crow reservation maintains that including some traditional cultural activities such as hand games, dancing competitions, or teepee raising in the mathematics curriculum might enrich these students' sense of purpose for studying mathematics and help them make meaningful connections between mathematics and everyday life. However, Julia described another constraint that limits her use of traditional Native culture in the classroom. She has found a resistance from some students towards having a non-Native teacher talking about things related to their culture.

Teresa also talks about connecting mathematics with students' lives but the nature of that connection is unclear. In the time I observed Teresa, I did not find any evidence of her use of culture. Lack of time and resources are the two limitations she finds most constrain her use of contextualization in the classroom.

Modeling and Demonstration

According to research, teacher use of modeling to prepare students to learn a new skill, process, or procedure or to reinforce a previously introduced one has been proven to be effective for American Indian students' learning of mathematics (Hilberg & Tharp, 2002; Nelson-Barber & Estrin, 1995; Pewewardy, 2002). Numerous findings support the view that Native American students are visual learners that seem to learn best when they are able to see the material they are expected to master (Tharp, 1994). However, researchers advise that modeling must not be relegated to repetitive and craft-making tasks (Lipka et al., 2005). For modeling to be effective with American Indian students, research says, the teacher should coordinate verbal and physical modeling to make visible and explicit thinking strategies that experts use in particular domains (Lee, 1995 in Lipka et al., 2005).

As research recommends, all four teachers use modeling in their classroom although they do it in different ways and not always aligned with research recommendations. While Laura and Ronda frequently model both the procedure and the thinking process, Teresa's modeling is mostly procedural. Julia also models both the procedure and the thinking process but often tries to let students start without any guidance. This normally does not work and she ends up modeling an example or two. She keeps doing it because she believes students need to gain experience thinking on their own. Julia, as well as Teresa, has noticed that having not enough guidance or modeling from the teacher often leads to student frustration. For the most part, all four teachers use modeling for simple tasks and procedures.

Ronda's cultural background, Native American, once more seem to shape her beliefs about the efficacy of modeling. She agrees with research that modeling fits the traditional teaching styles of many American Indian cultures, which encourage long periods of observation and reflection only after which performance is expected (Hilberg et al., 2002; Tharp, 1997). Traditionally, Native American students have been taught at home and in the community by observing parents or elders who generally teach through demonstration (Lipka et al., 2005). Ronda also believes that modeling has a lot to do with the traditional way of children learning at home. From birth to the time they get to school, she says, children learn a vast amount at home by modeling (how to speak, how to talk, etc…). Ronda believes that if it works at home, is only natural to keep using modeling as a teaching strategy once children start school.

Teresa's belief about the efficacy of modeling appears to be shaped by two lenses. On the one hand, she experienced in the past that her students need to see how something

is done before they attempt to do it. On the other, her belief seems to be strongly influenced by what she learned from a former professor in college who told her: "If you want them to do something, model it for them, and *then let them do it.*"

Furthermore, Teresa's procedural understanding and implementation of modeling differs from the one given by the research. The apparent philosophy of mathematics underlying the lessons I observed her teach, which seems to be built around computational procedures, is imbedded within the district curriculum that promotes procedural mathematics and the state testing that promotes a "mile-wide" coverage of topics. This could account for Teresa's implementation of modeling and explain the discordance between her definition and the one given by the research. However, this study did not explore teachers' beliefs and understandings of mathematics, so the previous argument, based only in my own interpretation from classroom observations, is merely hypothetical.

Teresa, Ronda and Julia believe Native students feel more comfortable having some guidance and are not eager to try something unless they have had some previous direction. Laura, on the other hand, and despite her constant use and value of modeling in the classroom, believes that letting students try to discover something in small groups (without the teacher modeling first) is also a good strategy since students get excited about mathematics when they discover strategies on their own. She also believes that, while doing it, students share their ideas, model to and learn from each other. In our conversations about modeling teachers brought up the concept of *discovery* as the opposite strategy to modeling. Discovery, as understood by the teachers, consists of letting students try to solve a problem without any guidance or previous modeling from the teacher. Julia, for example, often tries

to do so with her Native American students but has yet to succeed. She, as well as Teresa and Ronda, believes that not having enough guidance or modeling from the teacher often leads to students' frustration. The three teachers agree with research that most Native American students need to see how something is done before they attempt to do it. Laura, on the other hand, disagrees and, despite her constant use and value of modeling, she believes that letting students try to discover something in small groups (without the teacher modeling first) is also an effective strategy that motivates students to learn. Ronda believes that discovery might work sometimes but only if is timed and focused. She believes that if students one left to struggle for too long or about a very broad topic they will get frustrated and give up.

The four teachers talk about discovery as the opposite strategy to modeling. None of them talk about the possibility of modeling, for example, inquiry strategies that would aid discovery.

Joint Productive Activity

Research indicates that American Indian students tend to favor cooperation over individual work and competition (Hilberg & Tharp, 2002; Pewewardy, 2002; Swisher, 1990). According to many American Indian/Alaskan Native observers, Native cultures place more value on cooperation, sharing and contributions to the group than on individual achievement (Chavers, 2000; Swisher, 1990). There is security in being a member of the group rather than being singled out (Swisher, 1990). However, research says, schools do not typically teach in this manner and students are often expected to complete much of their work individually (Hilberg & Tharp, 2002).

Native children, research says, traditionally developed into competent members of their families and communities by engaging in dialogue and joint activity with more experienced members of the community (Hilberg et al., 2002). Therefore, it seems that for Native American students learning is optimized when experts and novices engage in dialogue while working together for a common product or goal (Tharp, 1997 in Hilberg et al., 2002). Some researchers have named that strategy "joint productive activity" (Hilberg et al., 2002).

All four teachers agree with the literature that setting students to work in groups is an effective strategy for Native Americans in mathematics. They also agree with research that by working in groups, students can help and learn from each other, and that Native American students feel comfort in the group and uncomfortable and exposed when they have to share their ideas individually. Three of the four teachers in this study consistently encourage and implement group work in their classrooms.

However, once again, each teacher has her personal understanding of *group work* which not always aligns with the definition of *joint productive activity* given by research as effective for Native American students in mathematics.

Laura and Julia believe that individual work is more effective than placing students into groups for certain tasks. Laura talks about tasks that require a deep level of concentration, while Julia puts her students to work independently when she does individual evaluations, in cases where there are great differences in students' skills, and when there is a social or behavioral problem among the students in the classroom. Teresa does not encourage or discourage group work in her classroom. Teresa and Julia, both high school

teachers, believe it is important to let students choose if they want to work in groups or individually, respecting personal space. They are aware of the complexity of social relationships in high school and how important is to be aware of that when setting students into groups to avoid potential conflicts in the classroom.

When the four teachers talked about strategies in which the teacher and the students work together, they referred to a situation in which the teacher is sitting with the students and is working on the exact same task as them. They all took that reference from one of the videoclips used during the first interview. The teachers have different beliefs regarding this strategy. Laura does not believe it is an effective strategy and thinks the teacher has to be circulating in the classroom, guiding and encouraging students. Julia, on the other hand, believes it is an effective strategy when they are working on a hands-on task but not a good one for more abstract activities when, as Laura, she believes the students will benefit from the teacher circulating in the classroom. Finally, Ronda said that it had never occurred to her but she believes it is probably a great strategy since while working on the same task as the students, the teacher can model not only the process but also the working behavior. Ronda said she is willing to try it in the future. It is important to take into account that except for Julia, none of the teachers uses that strategy.

As mentioned above, researchers agree that most Native students perform better when working cooperatively in groups, rather than competitively as individuals because they are accustomed to solving problems in this manner and often feel “put on the spot” in those situations where they are called on individually (Hilberg & Tharp, 2002; Pewewardy, 2002; Swisher, 1990). While research points out that many Native students prefer cooperative

learning strategies and that competition does not produce motivation, it also says that they find enjoyable activities that bring them together with friends or acquaintances in shared group activities. A good example is athletic events (Adams, 1995 in Pewewardy, 2002). Individual competition is considered unfair but in team sports, where performance is socially defined as benefiting the group, Native students can become excellent competitors (Pewewardy, 2002). These findings fit well with Laura and Ronda's beliefs regarding group and individual competition in the mathematics classroom. Both elementary teachers believe that while individual competition often discourages students, group competition is an effective strategy for Native Americans in mathematics that strongly motivates students to learn and improve their mathematical skills. Both Laura and Ronda often use group competition in their classrooms, and both agree that most of the time it is a very effective strategy.

The understanding that both Laura and Ronda have of group competition as a strategy that allows students to help one another and to share and discuss different ideas for solving problems together is in fact a true form of joint productive activity. Despite the fact that the teachers are usually not included in the competition, students engage in dialogue while working together for a common product or goal. Neither Laura nor Ronda ever seems to try to simulate that type of joint productive activity in other aspects of their lessons other than in game situations.

High school teachers Julia and Teresa, on the other hand, did not talk in the interviews about competition as a strategy and they did not use it in their classrooms during my observations. The differences in the intrinsic nature and structure of high school and

elementary school could be behind this disparity on using competition in both grades.

In the following chapter the findings described above will be summarized and a discussion on the implications of this study will be presented, including some suggestions for further research.

CHAPTER 5

CONCLUSION

In the following pages, the conclusions and implications of this study will be presented including some suggestions for further research. The chapter has four parts: (1) introduction to the study, its background and its methodology; (2) summary of the findings; (3) discussion of the findings; and (4) implications of the study and suggestions for further research.

Introduction

Mathematics education is failing American Indian students (Indian Nations at Risk Task Force, 1991). Extensive research has been conducted to find teaching strategies that might help improve the learning of mathematics for American Indians in schools. Despite the variety of cultural, linguistic, socioeconomic, and geographic factors influencing student learning within and among American Indian communities, common characteristics of learning styles and best teaching practices have been identified (Lipka, 2002; Hilberg & Tharp, 2002; Pewewardy, 2002). Though the wording in each definition varies, research based on a variety of theoretical frameworks and using a variety of methodologies and instruments suggests that among American Indian students, there is a tendency to learn better when teaching is contextualized, when collaboration among students and teachers is fostered,

and when modeling and demonstration is used and reflection is encouraged (Hilberg et al., 2002).

Most of the studies on effective strategies for American Indians in mathematics have been done based on previous research on the learning styles of American Indians. There is a general agreement in education research that the beliefs that teachers hold about mathematics teaching and learning greatly impact their instructional decisions in the classroom. However, not many of those studies, if any, have asked teachers what their teaching experience has taught them about effective strategies for their American Indian students in mathematics.

The main purpose of this study was to add the voices of four teachers to the research community conversation about effective teaching strategies for American Indians in mathematics. To do this, I identified the beliefs of four teachers with particular focus on the three teaching strategies mentioned earlier, giving them the chance to express their views about other practices that may be important to them. The study sought to offer a window into the complex phenomenon of teachers' pedagogical strategy choices and to shed some new light on the research and gaps that apparently exist between research and practice. The research questions were:

1. What are the beliefs of teachers who work with American Indian students in mathematics regarding the following teaching strategies identified by research as effective teaching strategies for American Indian students in mathematics: contextualized instruction, teaching through modeling, and joint productive activity?

2. What concordances and discordances exist between the beliefs of teachers who work with American Indian students in mathematics and research findings on effective teaching practices for American Indians in mathematics?

Four teachers were selected for this study. The four teachers break the stereotype of teachers in communities of poverty. Through their extensive experience and commitment to the mathematics education of children, particularly Native American students, I believe they have gained a perspective worth examining on the issue of effective teaching strategies. The teachers are two elementary teachers from Burton Intermediate and two mathematics teachers from Mountain High School. Burton and Mountain belong to the same county in Montana, one of the poorest in the United States. Burton is an off-reservation border town. Mountain is the largest town on the reservation. Burton Intermediate offers third, fourth, and fifth grades, and 59.0% of the student population is American Indian. Mountain High School has a 100% American Indian student population. Ronda and Laura teach fourth and fifth grade at Burton Intermediate. They are both young teachers, each with seven years of teaching experience. Ronda is American Indian and Laura is White. Julia and Teresa are both veteran teachers of mathematics at Mountain High School. Teresa is American Indian while Julia is White.

The method of data collection used in this study was a modification of videoclip interviews (Speer, 2002). The data collection lasted almost two months during the spring of 2007. It included three weeks of classroom observations, two videoclip interviews, a validation interview, and the videotaping of four classroom periods per teacher, except for Teresa whose classroom, due to scheduling conflicts, was only videotaped three times (a

detailed description of the data collection is given in Chapter 3). During May of 2007, I observed each of the four teachers for a classroom period per day, five days a week for three weeks. During the last of those three weeks I also videotaped four classroom periods per teacher (three for Teresa). A selected series of research-based video clips ("external videos") was used as prompts for the first interview which took place in the two weeks following my observations, depending on teachers' availability. In that first interview, the teachers watched the videos, and after each clip they were asked to comment on the strategies used in the videos as well as to identify which of the strategies were relevant or not to their students and why. After the first videoclip interview, a summary of each teacher's beliefs was written and given to them. Shortly thereafter, a validation interview was conducted offering each teacher a chance to comment on the accuracy of the written summary. Based on the classroom observation notes, the first videoclip interview and the validation interview, excerpts of the videos recorded in teachers' classrooms were selected and used two weeks later (also based on teachers' availability) as prompts in a second videoclip interview. In this final interview, the teacher and I continued our conversations about beliefs of effective teaching strategies for American Indians in mathematics.

With the data collected, a summary of beliefs regarding effective teaching strategies for Native Americans in mathematics was written for each of the four teachers. After that, teachers' beliefs were compared with research definitions of the three teaching strategies selected for the study to find whether concordances or discordances existed.

Summary of Findings

In this section, a summary of the findings is presented. First, the following three tables summarize the four teachers' beliefs regarding effective teaching strategies for Native American students in mathematics. A brief summary of the findings regarding concordances and discordances between teachers' beliefs and research findings follows after the tables.

Teachers Beliefs (Question #1)

Table 8. Teachers' Beliefs Regarding Contextualization

MODELING AND DEMONSTRATION			
Teacher	Definition/Practice	Effective/Not Effective	Limitations
Ronda	Builds a unit around a mathematical concept and imbeds familiar context into the unit to introduce new concepts, then moves on.	Is an effective strategy because when students make connections with their lives they learn better Building units around a context imbedding the mathematics into it would be a more effective strategy but……→	… it is time-consuming and requires the teacher to get out of her comfort zone.
Laura	Builds a unit around a mathematical concept and imbeds familiar modern contexts as practical examples of the math concepts.	Connecting mathematical concepts with students' lives is effective because: • It helps students make connections with things they know sparking their memory and interests, and • It gives purpose to school mathematics.	Feels limited when bringing in traditional culture due to her lack of knowledge of the Native American culture.

Table 8. Teachers' Beliefs Regarding Contextualization (Continued)

MODELING AND DEMONSTRATION			
Teacher	Definition/Practice	Effective/Not Effective	Limitations
Teresa	No evidence of her exact definition/use of contextualization.	Connecting mathematics with students' lives is effective because it makes mathematics relevant to students and helps them to: • learn better, and • remember better.	It requires a lot of previous preparation; it is time-consuming and requires the teacher to get out of her comfort zone.
Julia	Brings real contexts to the classroom in two ways: • Builds a unit around a mathematical concept imbedding real context into it; and • Builds a unit around a real context imbedding the mathematical concept into it. Uses modern culture more often that traditional because…….→	Connecting mathematical concepts w/ students' lives is effective because: • Students are more eager to learn, and • Students remember better. …students identify better with the "now culture" and……...……→	Finds it challenging to get students to draw the mathematics out of the context. …she has found a resistance from the students towards a White teacher talking about their culture.

Table 9. Teachers' Beliefs Regarding Modeling and Demonstration

MODELING AND DEMONSTRATION			
Teacher	Definition/Practice	Effective/Not Effective	Limitations
Ronda	Models both the procedure and thinking processes involved in solving simple tasks. The opposite of modeling is *discovery*: students perform a task with no guidance or previous modeling from the teacher but…….→	It is an effective strategy because: • children have learned by modeling since birth, • it has always been the traditional way of learning for Native Americans, and • Native Americans need to see someone model the tasks they are to perform. … is only effective if it is timed and focused.	The biggest limitation to the use of modeling in her lessons as much as she would like is that it is very time-consuming.

Table 9. Teachers' Beliefs Regarding Modeling and Demonstration (Continued)

MODELING AND DEMONSTRATION			
Teacher	Definition/Practice	Effective/Not Effective	Limitations
Laura	Models both the procedure and the thinking processes involved in solving simple tasks. Models both correct and incorrect methods. Does not believe that Native Americans need to see modeled the tasks they are to perform. The opposite of modeling is d*iscovery*: students perform a task with no guidance or previous modeling from the teacher.	Discovery is very effective because it helps students to learn a valid skill and to develop problem solving strategies. Only effective if the student's goal is clear.	
Teresa	Models the procedure (solves problems step by step).	Modeling is an effective strategy because: • Native Americans need to see someone model a task before they attempt to do it; and • a professor in college told her "if you want them to do something, model it for them, and then let them do it."	

Table 9. Teachers' Beliefs Regarding Modeling and Demonstration (Continued)

MODELING AND DEMONSTRATION			
Teacher	Definition/Practice	Effective/Not Effective	Limitations
Julia	Uses verbal and visual explanations to model both the procedure and the thinking process involved in simple tasks and procedures. Tries implementing *discovery* in her classroom but ……→	It is an effective strategy because her students are not eager to attempt solving a problem without any guidance or previous modeling from the teacher. … is not usually effective because students struggle and give up.	Students have not been trained in previous school years to solve problems on their own without the teacher's guidance.

Table 10. Teachers' Beliefs Regarding Joint Productive Activity

JOINT PRODUCTIVE ACTIVITY (JPA)			
Teacher	Definition/Practice	Effective/Not Effective	Limitations
Ronda	Often puts students to work in groups and does group competitions. Her group competition strategy is very similar to JPA as defined by the research literature, except for the teacher's involvement. She has never worked on the same activity as the students but..... →	Both group work and group competition are effective because students get very motivated and help each other to find new problem solving strategies. … it could be a valid strategy and she is eager to try it.	Time devoted to mathematics is so limited.

Table 10. Teachers' Beliefs Regarding Joint Productive Activity (Continued)

JOINT PRODUCTIVE ACTIVITY (JPA)			
Teacher	Definition/Practice	Effective/Not Effective	Limitations
Laura	Frequently puts students to work in groups.	Is an effective strategy because students share ideas, get motivated, and find comfort in the group.	
	Her group competition strategy is very similar to joint productive activity as defined by the research literature, except for the teacher's involvement.	It is an effective strategy because students encourage each other and feel protected by the group even if they fail.	
	Sometimes tries individual competition but……..→	… is not effective because it intimidates students.	
	Uses individual work for tasks that require deeper level of concentration.	Is effective because students focus better when they are alone working at their desks.	
	She never works on the same project with the students because…...→	…the teacher needs to be moving around, interacting, helping, and encouraging students.	

Table 10. Teachers' Beliefs Regarding Joint Productive Activity (Continued)

JOINT PRODUCTIVE ACTIVITY (JPA)			
Teacher	Definition/Practice	Effective/Not Effective	Limitations
Teresa	Teresa's definition of group work involves students working together solving book assignments. In her classroom, students work alone for the most part. She does not promote or discourage group work because……..→	Group work is effective because students can help and learn from each other. … she believes some students prefer to work alone.	Sees her classroom's furniture arrangement as a limitation for students working together.
Julia	The students sit in groups of three or four and work in groups often and in a natural manner. Works on the same tasks as the students only in hands-on activities but……→ Occasionally makes students work individually but….→	It is an effective strategy because talking math with another person makes it meaningful and helps the thinking process. … the strategy is only effective for hands-on activities. …. usually only effective for individual evaluations and when discipline problems exist.	Students' social relations and different levels of skills limit the teacher's options when using group activities.

Teachers' Beliefs and Research Definitions (Question #2)

Contextualization. The four teachers agree with research that mathematics teaching is more effective for Native American students in mathematics when the content is connected with the students' lives. However, within the group of teachers in the study we have a teacher whose definition of contextualization is unclear, two elementary teachers whose definition of contextualization consists of imbedding short real-world examples into an otherwise purely mathematical lesson, and a teacher who shares the research definition of contextualization but points out some of the limitations she has encountered while implementing it in her lessons.

Teaching through Modeling and Demonstration. The four teachers value modeling as an effective teaching strategy for Native American students in mathematics. Three of them agree with the research idea that Native American students learn better when they are able to see someone demonstrate the procedures they are expected to master. Their understanding of modeling, however, limits the meaning of the strategy intended by the research to the modeling of simple tasks and procedures. Teachers define discovery activities as those in which the students perform a task with no guidance or previous modeling from the teacher. They see discovery as the opposite strategy to modeling without acknowledging the possibility of modeling inquiry strategies.

Joint Productive Activity. The four teachers seem to agree that group work is an effective strategy for Native American students. Their understanding of group work,

however, differs significantly from the research definition of joint productive activity. Teresa's use of group work is the simplest, limiting the strategy to students optionally sitting close to each other and occasionally comparing results. Julia's students work in groups often and in a very natural manner. Still her use of the strategy is far from the complexity of the one given by research. The understanding that both Laura and Ronda have of group competition is a strategy very close to joint productive activity but neither of them seems to replicate that type of strategy into other activities besides games.

Discussion

Teachers' beliefs about teaching strategies, their understanding of a strategy, and the translation of a strategy into actual classroom practice seem to be idiosyncratic to individual teachers and appear to be shaped by multiple "*lenses.*" In my conversations with the teachers during this study, some of those lenses emerged including the teachers' cultural background, their previous personal and professional experiences, school structures, and their philosophies of mathematics, teaching and learning. In the following pages I analyze those lenses, exploring how they shape what teachers believe about effective teaching strategies and how they implement them in their classrooms, and how they might account for the discordances between teachers' beliefs and research findings regarding effective teaching strategies for Native American students in mathematics.

School Structures

Based on the interviews with teachers regarding their beliefs about effective teaching strategies for Native Americans in mathematics, it seems clear that teachers do not always manage to implement in their classrooms the strategies they believe are effective with their students. Sometimes they get to implement the strategies but not in the way they believe they should, or as often or for as long as they would like to. The reasons for this could be many, but it seems that a constant tension exists between teachers' beliefs and school realities. I believe this duality between ideals and obligations influences, individual teachers' understanding of research-based strategies as well as their translations of those strategies into classroom practice. As Hawthorne (1992) points out in her book *Curriculum in the Making,* teachers deal with multiple, competing, and, at times, conflicting influences upon their schools' realities and they pick and choose depending upon circumstances. Many teachers struggle to maintain equilibrium between their beliefs and the reality they face each day in terms of the nature of school, resources, time, etc., in an effort to survive the school year while doing what is best for their students. Decisions about what happens in a classroom, such as what materials are used, what is taught or how it is tested are frequently removed from teachers' hands (Hawthorne, 1992). Teachers, therefore, need to find and creatively modify strategies that remain true to their personal and professional beliefs while at the same time address the demands and reality of their schools. It is often the case that teachers show strong beliefs and ideals regarding what is best for their students, but at the same time demonstrate little faith that those ideals can be achieved in their school settings.

These findings agree with Brown's (1985) and Cooney's (1985) study of Fred presented in the literature review in Chapter 2. Brown documented discrepancies between Fred's beliefs and practice and Cooney described the tensions and conflicts that Fred experienced between his strong views about mathematics teaching and his perceptions of the realities of his teaching situation, which he claimed imposed numerous obstacles to implementing his views. Pressure to cover subject matter and maintenance of class control forced Fred to compromise his beliefs about instructional goals.

In the present study, examples of school structures that appeared to influence the teachers' beliefs and rationales would include the incorporated curriculum both schools have, the time that Laura and Ronda need to devote to Accelerated Math, and the fact that there was no chalk for Teresa to use in an outdoor activity involving a human graph. Regarding contextualization, for example, Ronda normally builds a lesson around a mathematical content imbedding some familiar context into it to introduce the new mathematical concept. She believes, though, that contextualization, as presented by research (a unit is built around a context and the mathematical content is imbedded into it), is probably more effective for her Native students. However, she says she cannot do it very often because that would be too time consuming. So the time constraints imposed by the school structures (the time used for the Accelerated Math program and the limited time devoted to mathematics) prevent Ronda from using a more complex version of contextualization that she believes could be more effective than the one she uses in her classroom.

The structure of schooling includes *present* structures as well as *perceived* structures or limitations. Sometimes teachers perceive limitations in their schools that do not necessarily exist. An example of this could be when Teresa says she wishes she could have big tables to do more group work but then does not want to group desks together to form tables like Julia does in the room next door.

Cultural Background

In this study we also find many examples of how the cultural background of the teachers influences both the teachers' definition and understanding of the strategies as well as their implementation in the classroom.

Ronda, again, is a good example; her cultural background strongly influences her appreciation for contextualization and modeling as effective teaching strategies for Native students in mathematics. Ronda is Native American and has grown up learning at home by modeling and by using nature for contextualizing new knowledge. She believes this has always been the traditional way of learning for American Indians and therefore she thinks they are both still valid strategies today.

Cultural background though does not necessarily shape teachers' beliefs in the same way. An example of that is how Julia and Laura, the two White teachers, both found themselves limited in their use of traditional Native culture in the classroom due to not being Native American. However, their limitations are different. Laura feels a limitation in the use of traditional Native culture because she lacks the knowledge needed to do it properly. Julia, however, has the knowledge but in the past she has experienced a resistance from her students towards having a White teacher talking about things related to their Native culture.

It was interesting to see how Teresa, a Native American woman born and raised on the reservation and very involved in the community, never referred in our conversations to the traditional learning styles of Native Americans. Ronda, in contrast, did so frequently. Speculating why this might be, I wondered whether or not Teresa might carry on a view, rooted in the history of the community and the boarding-school traditions from earlier decades, in which school learning/teaching is seen as distinctly separate from learning and teaching in the home or community. Make no mistake about it: Teresa holds a strong appreciation for schools and education.

Personal and Professional Background

The personal and professional background includes, among other things, a teacher's years of experience, academic background, and specific professional and personal experiences. The strong influence that a professor in college has over Teresa's beliefs regarding modeling is a good example of this. When I asked Teresa why modeling is effective with her Native American students, she often referred back to a professor in college. It seems she deeply believes that modeling works, and it seems it is because that is what she learned in college.

Another example of how previous experiences shape teachers' understanding and implementation of the different teaching strategies is Julia's implementation of contextualization. Having an understanding of contextualization similar to the one presented by research and valuing the strategy as effective for her Native students, she has expressed her frustration regarding the challenge she faces in getting her high school students to draw the mathematics out of the context. Therefore, even though her theoretical understanding of

contextualization agrees with the one given by the research, her previous experiences implementing the strategy have often made her modify its implementation to a simpler strategy in which the mathematical content is the center of the unit and the context is imbedded to make it more interesting. She still believes that the research-based definition of contextualization should be more effective with her students but she has not yet found a proper way to implement it successfully. Her experience has not changed her beliefs regarding the strategy but her way of implementing it in the classroom.

This connects well with the literature review presented in Chapter 2 when Ball (1998) talks about how teachers may sometimes manifest their teaching ideals while knowing that those ideals cannot be realized perhaps due to the lack of knowledge, skills, or circumstances to implement them.

Another reason why discrepancies between teachers' beliefs and practice exist could be that even if the teachers have been exposed to the strategy and believe that it could probably be effective with their students, not having used the strategy themselves might prevent them from using it. Often teachers prefer to stay in their comfort zone in order to maintain a sense of control over their work. Not having experienced the strategy within their own school context might also prevent them from trying. Both Ronda and Teresa believe their use of contextualization in their classrooms is limited by their own traditional ways of teaching and the effort required to get out of their comfort zone in order to contextualize their teaching of mathematics as recommended by research.

Philosophy of Mathematics, Teaching and Learning

The understanding that teachers have of mathematics teaching and learning obviously has an influence on the way they teach and the beliefs they hold regarding teaching strategies (Calderhead, 1996; Pajares, 1992; Thompson, 1992).

Teresa's procedural approach to modeling could be a good example of this. Her approach might simply be a reflection of the apparent philosophy of mathematics imbedded within the district's curriculum that promotes procedural mathematics, and it might also be a response to the state testing system that forces a mile-wide covering of topics. All of this might account for the discordances between her operational definition of modeling and the one suggested by the research.

The lenses presented above, teachers' cultural background, personal and professional previous experiences, the school structures, and philosophies of mathematics, teaching and learning emerged from the data collected in the study. They shape what teachers believe about effective teaching strategies and the way they implement them in their classrooms. These findings are supported by previous research on teachers' beliefs about teaching as seen in the review of the literature in Chapter 2. In my study, however, all of those lenses (except perhaps some of the ones I used to interpret Teresa's beliefs and practices) have emerged from the teachers' conversations and not from my conjectures when analyzing the data.

Another lens that I failed to mention but that has profound influence on all the other external lenses identified above and therefore on teachers' beliefs and practices, including the three strategies explored in this study, is the socioeconomic background of the students.

The poverty most students face in the two schools involved in the study plays a fundamental role in everything that happens at the district level, the school level and in classrooms. In my conversations with the teachers, Julia and Teresa both brought up the issue of poverty when talking about their students' reality at school. However, none of the four teachers included in their conversations direct links between students' poverty and the three teaching strategies explored in this study. While the issue goes beyond the span of this study, I felt it was important to include Teresa's and Julia's comments found in Appendix F.

Implications

In this section, the conclusions and implications of this study will be presented including some suggestions for further research.

Mismatch between Research and Teachers' Definitions

There is an obvious mismatch between the research-based definitions of the three strategies selected for this study and some of the definitions given by the teachers. A clear example of this is the way teachers talk about joint productive activity. While research talks about the teacher and the students engaging in dialogue while working together for a common product or goal, the teachers did not really grasp this meaning of group work from the videos. They only talked about students working together on math problems or questioned the teacher sitting with the students while working in the exact same task as them. It could be that the strategies given by research as effective for Native American students in mathematics are quite specific and perhaps teachers are unaware of the full meaning of those strategies since they have never really been exposed to them. If they have

been exposed to these strategies, they might have looked at them with their own lenses which probably differ from the researchers'. Teachers and researchers might see different things when they observe the same teaching vignette. In this study, for example, the teachers were exposed to the research-based strategies through the videos featuring Ms. Sharp. However, their interpretations of the strategies the teacher used in those clips were not always the same as mine as a researcher.

When teachers look at research results, or in this case research-based teaching strategies, they do it through multiple lenses. As discussed before, those lenses shape their understanding of the teaching strategies as well as the translations they do of those strategies into classroom practice. Those lenses might change and even narrow the intended definition of the research strategies.

If we, as researchers, want to break the gap between teachers' beliefs and research findings, we need to start addressing those structures that shape teachers' understanding and implementation of the different teaching strategies. Researchers need to start addressing those lenses to either find constructive ways to change those structures that limit the intended implementation of the strategies or to explore possible modifications of the strategies so they can adapt and still be effective when implemented under different circumstances.

Research Teaching Strategies in Real Schools

Julia's experience with her students' resistance towards having a White teacher talking about things related to their Native culture opens up an interesting question. Perhaps research needs to explore how the strategies work in different settings including different teachers, as well as different school and classroom contexts. It is possible that different

settings might influence the efficacy of certain strategies even if students share the same culture, in this case Native Americans. In our study, for example, according to the teachers involved, group competition was only brought up as an effective strategy by the elementary teachers and not for those in high school. For researchers to truly help teachers understand and implement the strategies they have found to be effective, they also need to better understand how the strategies work in different real settings with different real teachers and students.

After reviewing the literature on effective strategies for Native Americans in mathematics and spending time in the schools observing classroom practice and talking to teachers about it, it seems to me that research activities used to test the efficacy of certain teaching strategies do not necessarily fit school realities. Even when the research is implemented across diverse school settings presumably to see what works in a range or real world contexts, constraints that teachers typically face are often temporarily relaxed or removed by the cooperating schools or districts to allow the research to go forward. As a result, the target strategies may be shown to "work" under conditions that are only superficially like the conditions the same teachers normally face. Perhaps as researchers we need to focus less on investigating promising strategies under ideal conditions and more on testing them under the conditions the teachers will face when the researchers have departed.

Teachers' Beliefs and Practices

Another reason why discrepancies exist between teachers' beliefs and practices could be that even if the teachers have been exposed to a teaching strategy and believe that it could probably be effective with their students, not having used the strategy themselves might prevent them from using it. As mentioned before, not having experienced the strategy within their own school context might also prevent them from trying it on their own. Teachers need to spend time experiencing those strategies in their own classrooms in order to decide whether they are effective or not with their students.

To bridge the research/practice gaps, the mathematics education community should find better ways to provide opportunities for real teachers to experience those strategies in their own contexts. In this way, teachers would have a better sense of what those strategies mean and it would be easier for them to understand how the strategies fit their school and whether or not they would be effective for their students. Teacher education should also acknowledge this by preparing pre-service teachers to see beyond the theoretical definition of the different teaching strategies and by providing opportunities for the teachers-to-be to experience the strategies in real settings.

When talking about contextualization, Julia seemed to be the one who has the closest definition to the one given by research and even implements it on occasion in her classroom. She has expressed, however, her frustration regarding the challenge she faces in getting her high school students to draw the mathematics out of the context. This seems to be particularly challenging with high school students. Perhaps research can learn from Julia's

experience and explore (and educate teachers on) ways to efficiently move students from the contextualized to the more formal mathematics.

Teachers are a good source of information for research. Researchers can learn from teachers about the limitations they find when implementing different strategies. Later on, researchers could explore new approaches to overcome those limitations and perhaps assist teachers in finding effective ways to implement them.

Conclusion

Giving a rich description of the beliefs of four teachers devoted to improving the learning of Native American students in mathematics might not have helped us understand what all teachers believe about those teaching strategies, but it has given us a sense of some issues related to the connection between teachers' beliefs and practices as well as the correspondence of these beliefs with research findings. Below, I present a summary of the findings and implications of the study.

Three main implications for research are drawn from this study: (1) teachers' definitions of research-based teaching strategies often differ from the one intended by the research. Multiple lenses shape teachers' understanding and implementation of the different teaching strategies. When looking at the strategies, teachers have different perspectives that tend to be narrower than the research definition of the strategies. As researchers, we need to start addressing those lenses by either finding constructive ways to change them or by exploring possible modifications of the strategies so they can still be effective when implemented under different circumstances; (2) regardless of whether their beliefs are

aligned with prevailing research ideas or not, teachers do not always implement all of the strategies they believe would be most effective with their students. Teachers often face barriers that limit their use of certain strategies in their classrooms. The mathematics education community can help reduce these barriers by ensuring that promising teaching strategies are tested across a broad range of student populations, as well as classroom, school and community contexts. We can further help by implementing professional development approaches that offer teachers ongoing support as they make the adjustments that are inevitably needed for a promising teaching strategy that has been tested in someone else's classroom with someone else's students to be equally effective on their own; (3) teachers like Julia who understand the research and implement it in their classrooms have a rich, constructive perspective to offer to researchers. As researchers, we need to listen to those teachers and address the issues they have found in the implementation of those strategies in order to find better ways to approach the use of such strategies. Otherwise, teachers might see research results as theoretically valid but unrealistic and unlikely to work in their own school settings.

These implications align well with the National Council of Teachers of Mathematics (NCTM) Committee on Mathematics Education Research call for radical changes in the research paradigm for mathematics education (NCTM, 2006), promoting initiatives that encourage significant collaboration between researchers and practitioners. The need for improvement is bi-directional. Mathematics teachers need to be better informed about research results and to be helped to understand them in their own school contexts. Likewise,

researchers need to learn more from the insights and knowledge of teachers who work in diverse school settings.

Epilogue

I have known the four teachers involved in this study since the fall of 2003. They all teach in very challenging environments, facing a number of obstacles while trying to improve their students' learning. Since I started working with these teachers, I have gained great respect for the teaching profession and an admiration for the strength they show when facing the challenges encountered every day. After our conversations and time spent together in their classrooms during this study, that respect and admiration has grown even more. The four teachers opened their classrooms and minds to me with no limitations and were patient with my intrusions and truly generous with their time. Despite their years of experience working with Native American students, the four teachers felt uncomfortable about me addressing them as experts. The teachers were always very critical of themselves; not once did they blame their students for not learning.

Issues of poverty and lack of support arose in the conversations and went far deeper than I could address in this study. One of the teachers, for example, turned off the tape recorder when she wanted to talk about how her school as a whole was failing their students. Pressure from national and state testing, accelerated math programs, and other structures imposed on them make these teachers' work more challenging every day. They still love their profession and they try harder each day to improve their teaching and to better help their students learn. Consequently, the participants in this study deserve our respect and

gratitude for unselfishly giving their time to help us understand a little better the connection between teachers' beliefs and practices as well as between teachers' beliefs and research findings.

I started this study with the conjecture that researchers in education can learn a lot from classroom teachers. The results of the study have confirmed this conjecture. To improve students' learning, the research community needs to find better ways of communicating and collaborating with practitioners. This includes finding constructive ways to share research findings with teachers and to create channels for teachers to provide feedback and share their experiences. Working together, researchers and practitioners can improve the learning of mathematics for all students.

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APPENDICES

APPENDIX A

INTERVIEW #1 TEACHERS' PROTOCOL

Selecting External Videoclips (Preparing for Interview # 1)

Prior to the first interview, a series of research-based videoclips were selected representing the three teaching strategies identified by the research as effective teaching strategies for American Indians in mathematics (i.e. contextualized instruction; joint productive activity; and modeling). The selected videoclips came from the research of Jerry Lipka based on the use of his Mathematics in Cultural Context modules (Lipka et al., 2005). All the clips are taken from the same K-1 lesson taught by Nancy Sharp, a Yup'ik Alaskan teacher. As agreed with the author, no full descriptions of the clips or any transcriptions are presented in this paper but they all can be found in the article: *The Relevance of Culturally Based Curriculum and Instruction: The Case of Nancy Sharp* (Lipka et al., 2005). The article is a strong validation of my videoclips selection. Besides that, to validate my selection of clips, I gave the research-based definition of the three strategies to a validation group and asked them to watch the entire video from which the clips were selected and tell me if they recognize the strategies in them and in which part of the video they did. The validation group was formed by a doctor of education and a doctoral student in mathematics education. They both selected the same time frames in the video that I had selected as clips for each strategy. After the selection was finalized, the interview protocol, presented in the next page, was designed.

INTERVIEW # 1
Teachers Protocol

First part

In this interview I will ask you to watch some clips from Ms Sharp class. All the clips are from the same lesson. I would like you to pay special attention to the teaching strategies Ms. Sharp uses and how students react to them. For each of the clips I will ask you the following questions:

1. Tell me your first impressions
2. Could you describe the type of strategies the teacher uses?
3. How effective do you think the strategies were for her students?

[Video Clips Transcriptions]

Second part (After watching all the videos)

In the second part of this interview I would like to ask you the following questions about each clip:

4. Which parts of the video do you find more relevant for you and your American Indian students?

5. Which ones are the least relevant?

6. How effective would the strategies the teacher uses in the video be with your American Indian students?

7. Have you tried that strategy? Is it something you normally do?

APPENDIX B

CLASSROOM OBSERVATIONS & VIDEOTAPING TIMELINE

Classroom Observations & Videotaping Timeline

Before any interviews took place, I observed teachers' classrooms for three weeks, five days a week, one period per day. Between the second and third week of the observations, I videotaped each teacher in her classroom while she was teaching mathematics during one period each day for four days. Due to teachers' scheduling conflicts, there were a couple of teachers that I could not observe every day and, for similar reasons, I only videotaped Teresa three times. A detailed calendar of my observations and videotaping date is offered bellow.

April 30 Laura Ronda Teresa Julia	*May* 1 Laura Ronda[2] Teresa Julia	2 Laura Ronda Teresa Julia	3 Laura Ronda Teresa Julia	4 Laura Ronda Teresa[3] Julia
7 Laura Ronda Teresa Julia	8 Laura[1] Ronda[1] Teresa Julia[1]	9 Laura[1] Ronda[1] Teresa[1] Julia[1]	10 Laura[1] Ronda Teresa[1] Julia[1]	11 Laura[1] Ronda[1] Teresa Julia
14 Laura Ronda Teresa Julia	15 Laura Ronda[1] Julia	16 Laura Ronda Teresa[1] Julia[1]	17 Laura Ronda Teresa Julia	18 Laura Ronda[1] Teresa Julia

[1] *Video Taped Lesson*
[2] *Ronda's lesson lasted only 30 minutes on Tuesdays*
(All the others, as well as the other teachers were 45 minutes periods)
[3] *Teresa's Lesson lasted only 30 minutes on Fridays*

APPENDIX C

INTERVIEW #2 TEACHERS' PROTOCOL

Selecting Internal Videoclips Interview #2

After videotaping the teachers in their classroom, I viewed the videotapes and selected excerpts from the video to use as prompts in the second interview. The selection of the excerpts was based on the teachers' comments from the previous interviews, on the data collected from the observations and on the three strategies identified by the research as effective for American Indian students in mathematics. The goal was to select clips that reflected the practices that represent the teacher's characteristic way of engaging students in joint activities; contextualizing instruction, and modeling mathematical processes. I also tried to identify and select particular actions done by the teacher that might have supported or contradicted some of the comments made by the teachers in previous interviews, as well as the three teaching strategies identified in the literature. To validate my choices, after watching the clips, each teacher was asked to elaborate on whether and to what extent the excerpts selected characterized or not her typical teaching. They all agreed that my choices were a faithful sample of their practice. One clarification was made by Julia on the reason why in one of the clips the only two students in the classroom were seating separated and not together (this is further explain in Chapter IV). Due to privacy agreements with the teachers and the schools, no copies or transcriptions of the videos are available. A basic protocol was build for the interview but, in general, the interviews were opportunistic and, as in the first interview, flexibility was permitted to pursue issues raised by the teachers as they discussed what took place in the teaching episodes. A copy of the protocol given by the teacher is presented bellow.

INTERVIEW # 2
Teachers' Protocol

First part
After watching each clip, I would like you to answer the following questions:

1. Tell me your first impressions
2. Could you describe the type of strategies you use in this video?
3. How effective do you think the strategies were for you students?
4. How typical was this clip in relation to your classroom practice?

Second part (After watching all the videos)

In the first interview we analyzed Ms. Sharp's classroom. We talked about the strategies she used and whether they were effective or not. Now we have seen some videos from your classroom and talked about your strategies. How would you compare you classroom practice with Ms. Sharp's?

APPENDIX D

PARTICIPANTS CONSENT FORMS

SUBJECT CONSENT FORM FOR PARTICIPATION IN THE STUDY

BELIEFS AND PRACTICES OF TEACHERS OF AMERICAN INDIANS IN MATHEMATICS

Researcher: Raquel Vallines Mira
Phone:
Email:

You are being asked to participate in a study that will investigate your beliefs and those of three other teachers regarding teaching practices for American Indians in Mathematics. I want to learn from you and I want your voice to be heard. My study will focus on the beliefs and practices of four experienced mathematics teachers who have been working with American Indian students from a particular reservation for many years. Teachers participating in this study are dedicated in their efforts to reach American Indian students in mathematics and have been attending professional development activities on a regular basis in which they reflect upon their students' learning. You have been selected for this study for being an exemplary dedicated teacher who is deeply concerned about her students learning.

If you agree to participate, I will observe you teaching your math class for at least a week (5 days, one period per day). Afterwards, I will videotape you in your classroom during four consecutive days, one class (period) per day. I will also conduct two one hour interviews with you in a place of your convenience. Both interviews will take place after the classroom observations. After each interview, a summary of our conversation will be written. You will have the opportunity to read the summary to validate and/or clarify the content. All interviews will be audio taped and schedule in a way that will not interfere with your class schedule (i.e. after school). Clips of the videos will be used during the interviews to give some context to the conversation. All the audio and videotapes will be stored in a locked cabinet throughout the duration of the study. No other person except for you and I will have access to those tapes. When I finish my study, all the tapes will be given to you to keep, no copies will be made or kept by me or anybody else.

Your participation in this study is entirely voluntary. You will be able to withdraw from the study at any time you want by simply notifying me. Your name will be kept confidential and a pseudonym will be used throughout the study and in the final report.

If you have additional questions about the study, please contact me at _____or _____. If you have specific questions about the rights of participants in this study, please contact the Chairman of the Institutional Review Board at Montana State University, Mark Quinn, (406) 994-5721.

AUTHORIZATION: I have read the above and understand the nature of my involvement in this study.
I, _____ *(name of subject),* agree to participate in this study. I understand that I may later refuse to participate, and that I may withdraw from the study at any time. I have received a copy of this consent form for my own records.
Signed: _____ Date: _____

Consent Letter for the Study (SAMPLE):

Beliefs and Practices of Teachers of American Indians in Mathematics"

I have read the attached document[1] describing the study named "*Beliefs and Practices of teachers of American Indians in mathematics"*. I agree and allowed Raquel Vallines Mira to interview and videotaped the following teachers: _____, and _____, during April and May of 2007. I understand the study will be run under the guidelines set forth in the description of the study "*Beliefs and Practices of teachers of American Indians in mathematics"* attached.

[1] A sample of the document given to the administrators describing the study can be found in the next page.

Beliefs and Practices of Teachers of American Indians in Mathematics

The study I am proposing will investigate teachers' beliefs about teaching practices for American Indians in Mathematics. For this study I wanted to work with four exemplary teachers that break the stereotypes of teachers in poor communities. My study will focus on the beliefs and practices of four (Indian and non-Indian) experienced mathematics teachers who have been working with American Indian students from a particular reservation for many years. These teachers are dedicated in their efforts to reach American Indian students in mathematics and have been attending professional development activities on a regular basis in which they reflect upon their students' learning.

The participation of the teachers in this study will be entirely voluntary and they will be able to withdraw from the study at any time they want. To collect my data I will observe and videotape each teacher in their classroom during four consecutive days, one class (period) per day. I will also interview the teachers three times (two one-hour interviews and one half-hour). All interviews will be schedule in a way that not interferes with teachers' class schedule (i.e. after school). The videotapes recorded during the classroom observations will be only watched by me and the teacher. Clips of those videos will be used during the interviews to give some context to the conversation. Nobody else will have access to those tapes and when I finish my study, all the tapes will be given to the teachers to keep, no copies will be made or kept by me or anybody else.

Two teachers have agreed to participate in my study from your school/district: _____, and _____. These teachers are exemplary dedicated teachers who are deeply concerned about their students learning. I want to learn from them and I want their voices to be heard.

Raquel Vallines Mira

Bozeman, March 06, 2007

APPENDIX E

TERESA AND JULIA TALK ABOUT POVERTY

TERESA'S REFLECTIONS ABOUT POVERTY

At the end of the interview I asked Teresa to think about how different will be to teach at Bozeman high school (one of the biggest cities in the state), with mostly middle-class white students compared to teaching at Mountain High. Her answer was:

> *I think it would be different because… they have a different background right down to where they will do their homework at home because they have a home. They have a bedroom, they have a quiet space in the house and they have the resources at home to do their homework. Whereas on the reservation, at Mountain, when you walk into a home, say there are 4 bed rooms in a home, there is a family in each bedroom. And to find that quiet space it is hard. Even with me, that is how my house is right now. Right now in the bedroom downstairs, my son's family lives there. The bedroom upstairs, my daughter's family lives there. And to find quiet space at home for me to work is impossible. So, what do I do? I have an advantage for my own kids, I have my classroom. So for my daughter, before we go home, I make her do her homework right there in the classroom. But the kids don't have that. That is the difference between Bozeman schools and Mountain.*
>
> *They probably come from healthier homes too… families where it is just the mom and dad and an only child or a couple of children. At home, a lot of our families deal with drugs and alcohol. Our kids have to deal with that. For a lot of them, their parents didn't raise them. Their parents are there but they don't raise them. Or sometimes their parents died because of drugs and alcohol. Just like in this typical classroom, Gina, her dad died and her mom chose not to raise her. She was raised by her grandma. Ever since Gina was in second grade, her mom sent her away to school and her grandma pretty much raised her. And this year her grandma died so she had no family. And her mom is in her life now. She is mad at her mom so she is constantly fighting with her. She lives with her mom and her boyfriend. Then, Charlie lives with his grandparents and Georgia is the only one that lives with her parents out of this whole group. John's parents are divorced. Julia's dad died, she is the one who lives with her boyfriend. Ryan, his parents died, both his parents died.*
>
> *Out of this whole classroom one of them lives with her mom and dad. Their survival is worrying about where are they going to sleep tonight and which foster home, which family is going to take them in next week. Within this group, I think Georgia is going to try to go to college. And probably out of this group three of them will try college, I don't know if they will finish but I have confidence that three of them will try it.*

JULIA'S REFLECTIONS ABOUT POVERTY

As mentioned before, Julia does not think there are big differences in the strategies that are effective for teaching mathematics to Native and non-Native students. However, she does believe that the socio-economic background of most of her students might affect the preparation and background they bring to school when they first start and the way they see school as they go through it.

When you look at a student who is raising her child or maybe more than one child, for her, learning geometry, probably isn't a major focus of her life. She may be dealing with an abusive boy friend and there are so many things of that sort going on in her life.... And you can kind of see that point of view in which school seem so trivial. But then you come to another one, not in this classroom but I have another girl, I know is raising at least two children, her own children, and she has a goal to become a lawyer and she is very focused on her academic work. I think she wants something different. I think somehow she has the goal and the knowledge that she has to master this if she is going to reach beyond what she sees in the community. And I am not sure what makes the difference between that girl and the others in the same situation. I think that might be some personal motivation in there.... I don't know where that comes from.