RESEARCH ON MATHEMATICS PEDAGOGY FOR AMERICAN INDIAN STUDENTS: PHASE III

Connecting Practices with Outcomes

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TABLE OF CONTENTS

FOREWORD

This report presents a research design for the third and final phase of a project examining effective practices for American Indian students in mathematics. The project is part of one line of work being conducted by Mid-continent Research for Education and Learning (McREL) in the area of standards-based education. The research addresses priority issues in the Central Region, including quality of curricula and instruction and effective practices for student subgroups. The purpose of this research is to expand the evidence-based knowledge about effective standards-based practices for improving American Indian student achievement.

In this report, we present the rationale, purpose, design, and methodology of the phase III study. The audience for this report includes leaders and researchers in American Indian education, and representatives of the project's funding agency, the Institute of Education Sciences in the U.S. Department of Education. Ultimately, McREL intends to use the knowledge gained from the proposed research to inform product development in the form of a teacher's guide and/or case examples. Such a product is intended to help teachers adopt standards-based mathematics instruction that enables students from culturally diverse backgrounds to meet standards important to their future success in school and life.

INTRODUCTION

American Indian students make up a substantial subgroup of the K–12 student population in two Central Region states. In South Dakota and North Dakota, American Indian students make up over seven percent of the student population, placing these states fifth and sixth highest among all states (U. S. Department of Education, 2002). In North Dakota, only 24 percent of the American Indian students performed at or above proficiency on the 2002 fourth-grade state assessments in mathematics (Dooley, 2003). If we are to take the goals of the No Child Left Behind Act (NCLB) seriously, such subgroup outcomes need to improve dramatically. Unfortunately, only a limited research base exists to inform practitioners and policymakers about how to make these improvements.

In the 1990s, Deyhle and Swisher (1997) recounted the history of research in American Indian and Alaska Native education. Prior to the 1960s, research was steeped in “a legacy of deficit thought and guided by assimilation ideology” (Deyhle & Swisher, 1997, p. 117). Native language and culture were viewed as barriers rather than resources. Few studies attended to social environment and school structures as essential factors in understanding student success or failure. And, generally, the voices and perspectives of American Indians were not included and researchers ignored tribal policies of self-determination. Improvements in American Indian education research occurred in and around the 1960s:

> The 1960’s seem to define a point of demarcation in Indian education. This decade marked the emergence of strong Indian leadership that led to a policy of self-determination. Consistently over the past two decades, the voices of Indian people have become stronger in determining all aspects of their children’s education, including educational research. More schools on reservations are now locally controlled, and research, once the domain of university researchers, has been demystified to include research partnerships with local people asking their own questions and constructing appropriate paradigms for finding solutions. (Deyhle & Swisher, 1997, pp. 180–181)

This report is one of a series of reports produced by a research partnership supported by Mid-continent Research for Education and Learning (McREL) involving researchers, teachers, local administrators, and state education and tribal officials. The partnership is engaged in a long-term research project that includes reviewing research and related literature on effective standards-based practices for American Indian and Alaska Native students, supporting professional development in research for American Indian educators through an intern and visiting scholar program, and establishing and maintaining a core group of partners to help direct and implement relevant and rigorous research for improving the educational outcomes of American Indian students. Current efforts focus on effective teaching practices for American Indian students in North Dakota. However, McREL plans to expand its partnership to include schools and educators from South Dakota and other Great Plains states.

In this report, a summary of project findings to date is presented, followed by a proposal for the Phase III study. Phases I and II, establishing the partnership and conducting initial studies, have been completed. Phase III work, which will be conducted from October 2004 to November 2005, builds on the preliminary work and findings of the prior phases.

STATEMENT OF THE PROBLEM

Our initial review of research for this line of work (Apthorp, Debassige D'Amato, & Richardson, 2003) led to conclusions similar to those reached by Deyhle and Swisher (1997). American Indian education research had made a difference in some contexts, resulting in significant achievement gains for American Indian students in some schools and some communities, notably, for example, in Rough Rock, Arizona (Deyhle & Swisher, 1997). Nonetheless, as Deyhle and Swisher argue:

> Still needed . . . is the interpretation of what this research means in the way teachers are trained, schools are organized, curriculum is designed, and instruction is delivered. (p. 182)

Researchers, practicing educators, and community members in Navajo and Hawaiian schools collaborated to conduct a comparative case study and two quasi-experimental studies. In these studies, students who received culturally based education with an emphasis on developing language and critical thinking performed significantly higher on tests of academic achievement in both language arts and mathematics than students in comparison groups (Holm & Holm, 1995; Rosier & Farella, 1976; Tharp, 1982). Whether or not similar approaches bring about similar outcomes in different communities, however, remains unexplored. In the studies cited, Hawaiian Native (Tharp, 1982) or Navajo students (Holm & Holm, 1995; Rosier & Farella, 1976) made up the majority in the participating schools. Many if not most American Indian students, however, attend schools where they are in the minority (U.S. Department of Education & U. S. Department of the Interior, 2001).

Without a strong research base, educators have had to rely more on ideological, rather than theoretically sound, empirical guidance when looking for ways to improve the achievement of American Indian students. The present research seeks to extend the relevance of the knowledge to groups of American Indian students not well represented in the extant research literature. This inquiry focuses on the effectiveness of promising practices in mathematics pedagogy for American Indian students in North Dakota. In the long run, data collection tools and analytic procedures developed and refined in this study can be used in research focused on other groups and local and state contexts beyond North Dakota. McREL is assessing the efficacy of some of the potential solutions available to educators — solutions that are theoretically sound, have promise for improving American Indian student achievement, but are short on research-based evidence regarding their effectiveness. The intended audience for this research design includes education researchers and representatives of this project's funding agency, the Institute of Education Sciences of the U.S. Department of Education.

OVERVIEW OF REPORT

This report begins with a brief summary of Phase I activities as well as findings related to the Phase II research questions. This summary provides the context for the focus on mathematics pedagogy and achievement for American Indian students in North Dakota schools. Next, the research design for the Phase III study is presented, including the overall design strategy, rationale, and methodology. The methods section provides details on sampling and data

collection and analysis. The design section concludes with a timeline of events and report deadlines.

RESEARCH CONTEXT: PHASE I AND II FINDINGS

As shown in Table 1, Phases I and II involved establishing collaborative relationships, developing preliminary instruments, and conducting descriptive field studies. This section of the report briefly summarizes Phase I and II findings and highlights conclusions and implications for the design of Phase III work.

Table 1. Overall Timeline for Three Phases of Research

Phase I: **Establishing Relationships** Year 1: Dec 2002–Nov 2003	**Phase II:** **Conducting** **Descriptive and Pilot Studies** Year 2: Dec 2003–Aug 2004	**Phase III:** **Conducting an** **Effectiveness Study** Year 3: Oct 2004–Nov 2005
• Establish collaborative relationships • Form advisory panel • Conduct informal survey	• Summarize descriptive findings • Develop/adopt instrumentation • Collect & analyze pilot data	• Design effectiveness study • Conduct effectiveness study • Produce report • Disseminate report

PHASE I ACTIVITIES

Phase I activities resulted in (1) a literature review (Apthorp, 2003) that identified key variables in American Indian student achievement and a research design for Phase II, and (2) a research collaborative comprised of two groups. This section begins by identifying and discussing key variables. This is followed by a presentation of the purpose, membership, roles, and responsibilities of two groups that were formed for this project, the Research Partnership and the Research Advisory Panel.

Key Variables

A major premise of this research is that learning is “best built on the experience, values and knowledge of students and their families, both personal and community-based” (Demmert & Towner, 2003, p. 8). Making connections between prior knowledge and experience and new learning, however, is not a simple matter of association. As described by Beals (1998, as cited in Tharp, Estrada, Dalton, & Yamauchi, 2000), “it is an active process of sorting, analysis, and interpretation” (p. 29). This research focuses on the use of *instructional conversations* or mathematics talk as a way for teachers to help students extend prior knowledge to develop understanding of the new.

The ability to facilitate mathematical discourse is a core mathematics teaching standard (National Council of Teachers of Mathematics [NCTM], 1991). Conversations are used to emphasize, model, and practice mathematical reasoning (Florian, 2001; Kilpatrick, Swafford & Findell, 2001; Stein, Grover & Henningsen, 1996). Tharp and Yamauchi (1994) define instructional conversation as “a dialog between teacher and learner in which prior knowledge and experiences are woven together with new material to build higher understanding” (p. 1). According to these authors, the dialogue is interesting, extended, and rational. It has a

substantive focus, involving in-depth exploration of complex and abstract ideas and reasoning, and results in a new level of understanding on the part of both the student and teacher. In addition to its academic and intellectual value, dialogue can reduce the distance between teachers and their students. Through the exchange of ideas, teachers and students construct lessons “from common understandings of each others’ experiences and ideas” and the teaching-learning process becomes “a warm, interpersonal and collaborative activity” (Dalton, 1989, as cited in Tharp et al., 2000, p. 33).

For instructional conversations to be interesting, extended, and rational, the questions posed and addressed need to be high-cognitive-demand questions. Low-cognitive-demand questions elicit factual recall, whereas high-cognitive-demand questions are probing and open-ended, seek meanings and interpretation, and elicit reasoning and explanations. Using a quantitative comparative study, Ben-Ari (1997) examined relationships between teacher behaviors, student verbal interactions in the classroom, and academic outcomes. The study was part of a larger research and development effort that extended the theory and research of Elizabeth Cohen (1994) on group work in heterogeneous classrooms. Using classroom observation data and results from a test of thinking that required defining, categorizing, and formulating conclusions, Ben-Ari (1997) found that the extent to which teachers posed intellectual challenges to students and encouraged them to engage in higher order thinking (e.g., asking, “What other ways could you approach the problem?”) was significantly and positively related to the extent of students’ verbal interactions, which mediated their performance on the test of thinking. Conversely, more teacher time spent disciplining or directing students, or hovering over groups, was associated with less verbal interaction among students and lower performance on the test of thinking.

A participatory learning environment is necessary for every student to feel inclined to engage in and benefit from instructional conversations. Qualities of a participatory learning environment are identified and discussed by Tharp et al. (2000) in their proposal for transforming teaching to achieve excellence, fairness, inclusion, and harmony. A participatory classroom has an explicit system of shared values and beliefs regarding inclusion, helpfulness to others, and mutual respect, all of which may be necessary conditions for effective instructional conversations, especially in culturally and linguistically diverse classrooms (Tharp et al., 2000).

To encourage participation of American Indian students, teachers might need to adopt different social conventions and norms. Swisher and Deyhle (1992) suggest that Indian children tend to avoid situations that challenge harmonious relations and individual humility: “For Indian children from certain groups, public display of knowledge that is not in keeping with community or group norms may be an unreasonable expectation” (p. 90). To create greater cultural congruence, diads and triads can be used for cooperative work and conversation rather than singling out students in front of the whole class. According to Tharp and Yamauchi (1994), other considerations important for creating cultural congruence for American Indian students include increased wait time, an emphasis on peer- and activity-based versus teacher-oriented discussions, slowed tempo of events and conversations, indirect eye gaze, and engagement when ready instead of by teacher command.

In academically successful and culturally and linguistically diverse schools and classrooms, teachers and school leaders adapt practices and structures to students’ interests and

cultures and students feel a sense of belonging (Allexsaht-Snider & Hart, 2001; Jamieson & Wikeley, 2000). Other research and perspectives, however, are equally clear that an over-emphasis on personalizing instruction is *not* effective (Chall, 2000). Effective mathematics instruction is academically dense and structured to include clear statements of goals and explicit definitions, explanations, and modeling, followed by guided and independent practice with corrective feedback in multiple contexts (Baker, Gersten, & Lee, 2002; Cardelle-Elawar, 1990; Chapin, O'Connor, & Anderson, 2003; Ysseldyke, Spicuzza, Kosciolek, & Boys, 2003). Therefore, not only are shared values of helpfulness and inclusion and students' sense of belonging key variables in this research, alternative explanations for success, such as use of structured, explicit teaching, also are addressed.

To summarize, research literature on the academic achievement of students in culturally and linguistically diverse classrooms and schools identified four key variables that are considered in our research:

- Quality and duration of mathematics talk
- Cognitive demand of teacher questioning
- Nature of participation structures and learning environment
- Extent to which teaching is structured

Research Partnership and Advisory Panel

In September 2003, McREL formed two groups to conduct research relevant to the needs of education practitioners and policymakers serving American Indian students in Central Region states. One group is a hands-on working group, the Research Partnership; the other is an Advisory Panel of researchers and American Indian education leaders. The membership lists of both the Research Partnership and Advisory Panel are provided in Appendix A.

The purpose of the Research Partnership is to conduct meaningful, methodologically sound research to improve the quality and outcomes of education for American Indian students in North Dakota elementary schools.[1] The Research Partnership is a hands-on work group comprised of teachers and administrators from local, tribal, and state education agencies in North Dakota and researchers from McREL. At least one member of the Research Partnership also serves on the Research Advisory Panel. Each member of the Research Partnership serves on a subcommittee and is responsible for assisting with the conduct of one or more aspects of the study (e.g., assuring protection of rights of human subjects and complying with tribal research policies, developing/selecting student assessments and other instruments, interpreting and using findings).

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[1] Although the intended scope of this work originally included schooling and outcomes for American Indian students in South Dakota, momentum and active membership currently represents North Dakota almost exclusively. Discussion of how to recruit and expand into South Dakota or other states and regions is an activity planned for the conclusion of Phase III.

The Advisory Board is a group of scholars and state and national leaders in American Indian education and research. The purpose of the Advisory Board is to guide the work of the Research Partnership through research plan and report reviews. Members of the Advisory Board have knowledge of and use high standards of quality in research. In addition to their research expertise, they bring to the project knowledge and experience in American Indian education and mathematics education.

Phase I Outcomes

Phase I activities and outcomes influenced Phase II work in several ways. Based on a survey of participants in a 2003 professional development workshop sponsored by the Bureau of Indian Affairs, McREL identified mathematics textbooks and approaches commonly used with American Indian students in North Dakota schools (see Appendix B). Three of these textbooks (Saxon, Everyday Mathematics, and Scott Foresman-Addison Wesley) and one approach (Cognitively Guided Instruction) became the focus of studies conducted in Phase II.

Networking and meetings between Research Partnership members and others confirmed and extended the identification of key variables and attributes of classroom interactions supportive of American Indian students' learning and achievement. Participants at a planning meeting in Bismarck in February 2004 discussed the adequacy of the conceptual model presented in Figure 1 as a preliminary way of relating key teaching variables to success in mathematics.

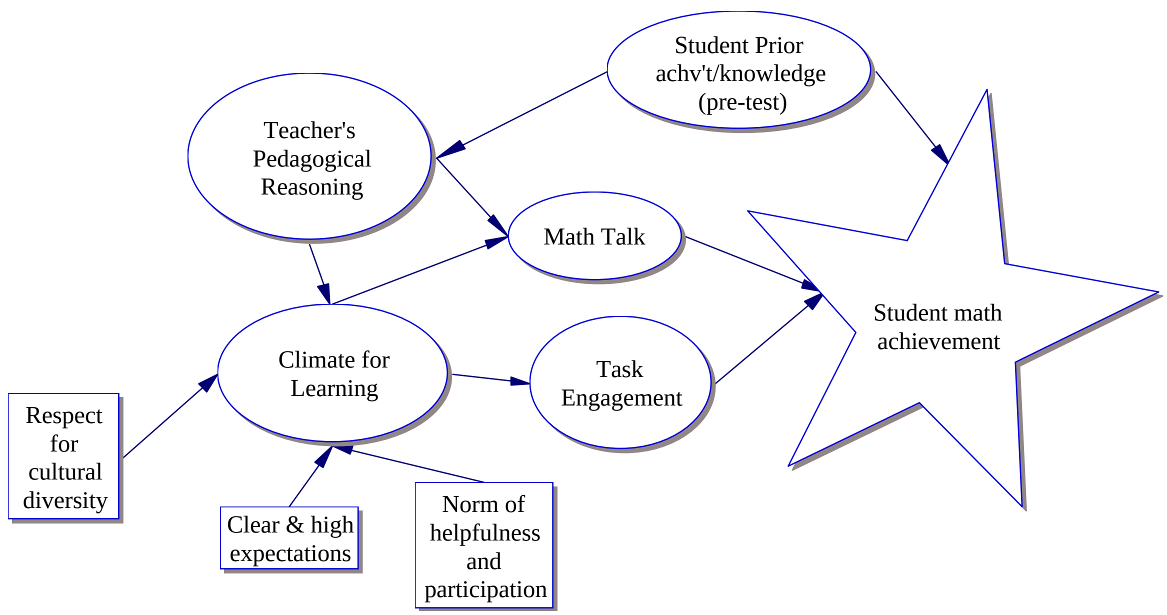

Figure 1. Conceptual model.

Participants added explanatory details to the conceptual model, such as language experience at home and residential stability as background factors contributing to prior knowledge. Distinctions were made between variables teachers had control over and those they

did not. Thus, the connection between students' prior knowledge and teachers' pedagogical reasoning was added to show that teachers use their assessment of students' prior knowledge to inform their pedagogical decisions. In particular, during the Research Partnership Meeting in February 2004, participants elaborated on the attributes of teacher-student mathematics talk that are effective for American Indian students, as follows:

- Is often based on experiences teachers have in common with students outside of school
- Makes connections for students by using students' experience and knowledge outside of school (e.g., conversations and problem-solving content include Indian tacos vs. egg rolls vs. brownies)
- Encourages and extends students' thinking (e.g., by asking students to explain their thinking and offering a variety of response modes, such as "show me," "draw it," "tell me," "write it," or "teach your partner how you did it")
- Is non-judgmental in comments or observations (does not put students down)
- Expresses high expectations (e.g., two-word responses from students are not acceptable)

PHASE II FINDINGS

The purpose of the Phase II work was to describe contextual factors important to mathematics pedagogy and achievement for American Indian students in North Dakota schools. The following Phase II research questions were specified:

1. To what extent are selected mathematics curricula and approaches used with American Indian students in North Dakota elementary schools aligned with content standards in mathematics?
2. What are the demographic and achievement characteristics of elementary schools serving American Indian students in North Dakota?
3. What data collection tools are reliable and valid for studying teaching practices and student achievement in mathematics in schools serving American Indian students?

Mathematics Curricula and Approaches

Standards documents specify and sequence learning targets in terms of the knowledge and skills expected of students and for which schools hold themselves accountable. The North Dakota state mathematics standards (North Dakota Department of Public Instruction, 2004) specify the mathematics knowledge and skills intended to represent what a person needs to know and be able to do to succeed in later schooling, at work, and in his or her community. Our first Phase II analysis was designed to evaluate the extent to which students had opportunities to learn these standards in the area of mathematics at grade four. We analyzed the alignment of content

between mathematics textbooks used in schools serving American Indian students and North Dakota's mathematics standards (North Dakota DPI, 2004).

Study Sample. McREL selected three mathematics textbooks from a list of curricular resources used by teachers in North Dakota schools serving American Indian students (see Appendix B for complete list); these were Saxon, Scott Foresman–Addison Wesley, and Everyday Mathematics. Grade 4 mathematics content as specified in 44 benchmarks was selected for analysis because of the significance of performance at the end of grade 4 in state and federal accountability systems.

Review and Analysis Methods. Lesson by lesson (or chapter by chapter), the analyst first identified all knowledge and skills covered in the teacher's manual for each mathematics textbook even if not explicitly included in the student pages. Then, the knowledge and skills were compared to the North Dakota grade four mathematics benchmarks. If no matches were found at grade 4, the alignment was conducted with benchmarks specified for grade levels above and below grade 4.

Findings. The analysis revealed equally comprehensive coverage of grade four mathematics benchmarks for the three textbooks. Each textbook covered 39 of the 44 benchmarks (89%) specified for the five North Dakota grade four mathematics standards. Figure 2 shows that (1) there is generally good alignment of the textbooks and the North Dakota standards and (2) no one textbook aligns perfectly with content standards.

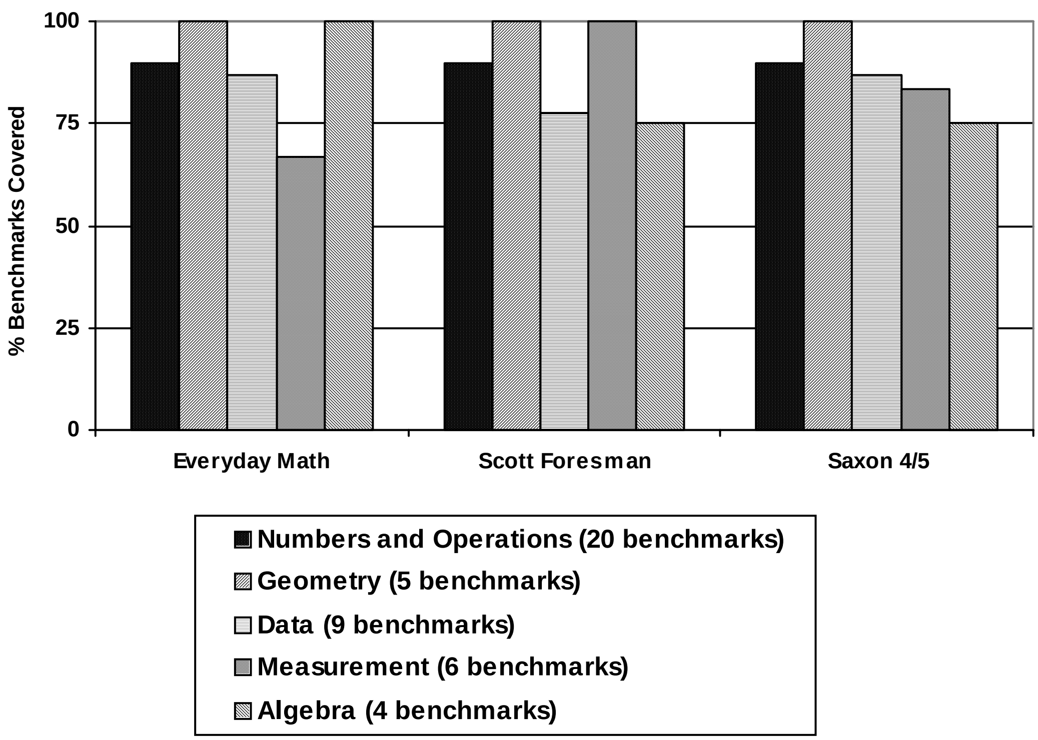

Figure 2. Selected textbook coverage of Grade 4 North Dakota content standards and benchmarks in Mathematics.

Although comprehensive, each textbook omitted some benchmarks. Across the textbooks, the missing benchmarks varied. As can be seen in Figure 2, Everyday Mathematics had the lowest coverage of Measurement benchmarks, but the highest coverage (100%) of the Algebra benchmarks. Although both Scott Foresman and Saxon covered three of the four Algebra benchmarks, each textbook omitted a different benchmark. Scott Foresman content did not include “use parentheses in solving simple equations,” and Saxon content did not include “determine the missing elements of complex repeating patterns.” (Uncovered benchmarks are identified for each textbook in the complete report [McREL, 2004].)

In standards-based systems, textbooks should not be viewed as drivers of the curriculum; rather, they should be viewed as resources from which to purposively select units and activities to help children learn important knowledge and skills. Curriculum maps and pacing charts help teachers organize instruction over the course of the academic year so that children have opportunities to learn critical knowledge and skills (Reichardt, 2002). An area for future inquiry is to determine the extent to which schools and teachers use pacing charts or other alignment and curriculum design tools to help ensure that American Indian students in North Dakota have opportunities to learn critical knowledge and skills.

Cognitively Guided Instruction. Cognitively Guided Instruction (CGI) is an approach to teaching developed by researchers who systematically studied and described children’s mathematical development and their intuitive problem solving (Peterson, Fennema, & Carpenter, 1991). CGI builds on children’s accomplishments and complements rather than contradicts what children already know and can do. Teachers trained in CGI develop a clear understanding of how students learn.

Along many dimensions, CGI is compatible with American Indian culture (Hankes & Fast, 2002). In CGI, for example, paired or group problem solving and solution sharing is emphasized and instruction is time generous rather than time driven. Also, the fact that CGI builds on children’s accomplishments and complements rather than contradicts what children already know is congruent with Native American pedagogy. In contrast to the metaphor of teaching where students are viewed as “blank slates onto which information is etched,” from the CGI and Native American perspective each student “is a born thinker,” constructing and revising emerging theories about the world (Hankes & Fast, 2002, p. 44). Furthermore, CGI is recognized as an approach particularly effective for culturally and linguistically diverse students (Tharp et al., 2000; Hankes, 1998).

North Dakota educators, including both local leaders and state officials, are interested in the potential of CGI, especially for developing American Indian students’ confidence, skills, and knowledge in mathematics (LaFromboise & Rasmussen, personal communications, 2004). Evidence from a study conducted in spring 2004 supports these appraisals of CGI. Teachers using CGI in North Dakota classrooms serving American Indian students report increased student confidence as problem solvers, increased excitement about learning mathematics through a “makes sense” approach, improved verbal skills for presenting in front of groups, and better understanding of numbers (Apthorp & Woempner, 2004). The problem is that no assessments of students’ knowledge and skills were made to verify the teachers’ reports. State and national regard for the possibilities of CGI (e.g., Tharp et al., 2000) warrant further study of its implementation and effectiveness.

Additionally, Apthorp and Woempner (2004) asked teachers how they perceived CGI's role in helping students meet standards. If a standards-based system is to impact achievement as intended — by clearly establishing what student must learn and holding students, teachers, administrators accountable — then curriculum and instruction must reflect or align with what is required in the standards (Clune, 2001; Ravitch, 1995). Teachers reported that CGI was an asset for helping students meet particular mathematics standards and benchmarks, namely, developing understanding of numbers, problem solving and communicating solutions to others (Apthorp & Woempner, 2004). As found for the alignment analysis above, where no one textbook aligned perfectly with content standards, CGI, as a pedagogical approach, did not align perfectly with every type of learning required by all content standards. Teachers supplemented their use of CGI with more explicit instructional strategies as appropriate depending on what students needed to learn. This purposeful alignment between instructional strategies and particular content was described by a teacher of combined-second and third-grade classroom as follows:

> Benchmarks such as identifying triangles or other shapes still have to be taught. Likewise, rounding, graphing, identifying coins, measurement, and the like need to be shown to the students for them to understand. The beauty of CGI is that once these concepts are established, story problems can be written to include these as well. The benchmarks involving number sense and number relationships are covered completely through CGI. Place value is a difficult concept, and I use a combination of CGI and demonstration for that. (As quoted in Apthorp & Woempner, 2004, p. 10)

Demographic and Achievement Characteristics

According to 2003 state data, there are 321 elementary schools in North Dakota, including public and Bureau of Indian Affairs (BIA) schools. Half of these schools serve student populations in which 1.5 percent or less are American Indian students. As shown in Figure 3, in about one-quarter (81) of these schools, American Indian students made up 1.6 to 5.3 percent of the student population, and in another quarter of the schools (80), American Indian students comprised 5.4 to 100 percent of the student population.

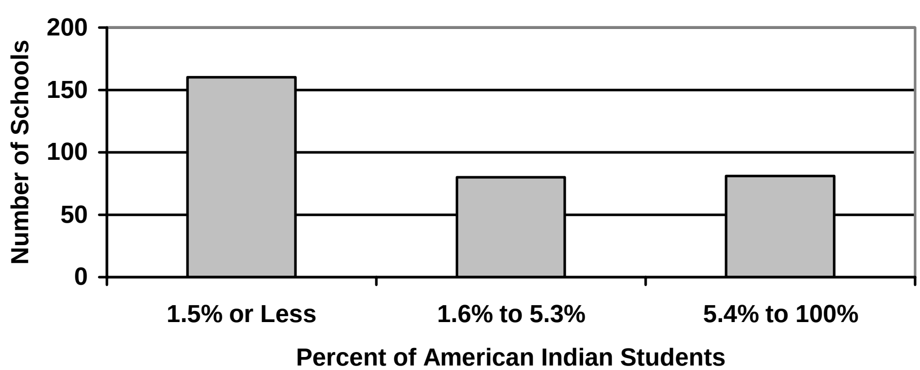

Figure 3. North Dakota elementary schools with different percentages of American Indian students.

The 80 schools with the highest percentage of American Indian students have an average free or reduced-price lunch (FRL) rate of 50 percent (ranging from zero to 98%). This is considerably higher than the state average FRL rate of 35 percent. The majority (78%) of schools with the highest percentage of American Indian students are either in rural locales (e.g., a 4-hour drive from Bismarck) or in mid-size cities (e.g., Bismarck or Grand Forks).

Mathematics achievement data aggregated at the school level were obtained from the North Dakota Department of Public Instruction. These data are the results of the state's criterion-referenced, standards-based assessment for grade four. The performance of American Indian students as a subgroup was available for 17 schools. In these schools, proportionally fewer American Indian students, compared to all students combined, performed at or above the proficient level. The gap between the achievement of American Indian students as a subgroup and all students combined is shown graphically in Figure 4. The average percentage of American Indian students who scored at or above proficient was 33 percent or less compared to nearly 60 percent for all students combined.

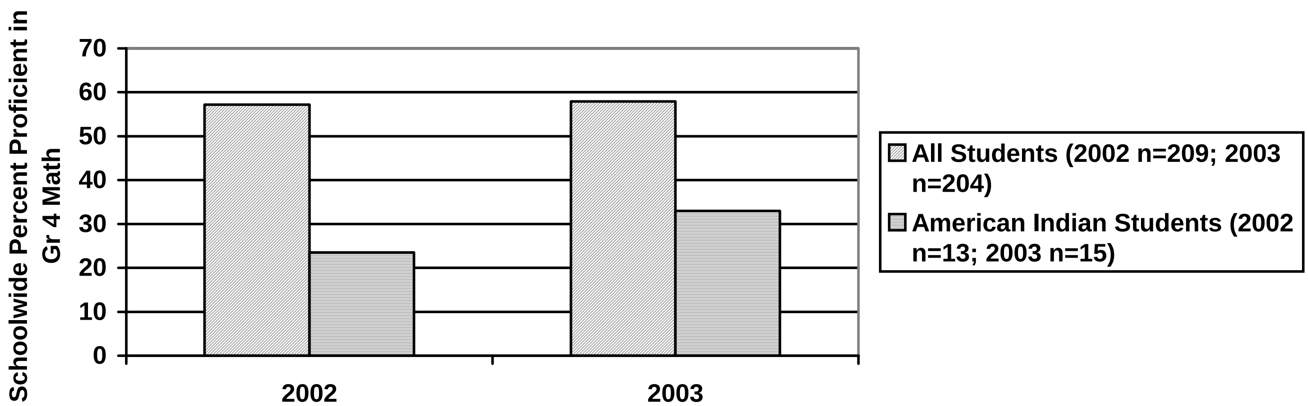

Figure 4. School average percentage proficient in grade 4 mathematics for all students and for American Indian students as a subgroup.

In five of the 17 schools with available subgroup data, the percentage of American Indian students who scored at or above the proficient level was relatively high. Descriptive information about each of these high-performing schools is presented in Table 2. These schools are potential study sites that will help extend the evidentiary knowledge base about effective practices in mathematics for American Indian students. Their demographic characteristics are comparable to the 80 schools represented by the right-hand bar in Figure 3 where American Indian students comprise over five percent of the student population. As potential study sites, they may offer lessons to be learned about how to effectively teach mathematics to culturally diverse groups of students, in particular, groups of students that include students with American Indian heritage.

Table 2. North Dakota Schools with High Percent Proficient or Above American Indian Students in Grade 4 Mathematics

	Grade 4 Mathematics Percent Proficient or Above				2002 School Composition		
	2002		2003				
	American Indian	Overall	American Indian	Overall	Total Enrollment	American Indian	FRL
Jeannette Myhre Elementary	-	31%	50%	57%	433	10%	53%
Parshall Elementary	38%	47%	47%	55%	158	68%	73%
St. John Public School	43%	47%	46%	46%	144	81%	83%
Minnie H. Elementary	-	64%	45%	63%	111	34%	51%
Lake Agassiz Elementary School	36%	47%	44%	70%	412	26%	60%

DATA COLLECTION TOOLS

Two Phase II activities examined the viability of data collection tools for assessing student mathematics achievement and classroom learning environment and practices. Appropriate student assessment was discussed at the February 28, 2004 Research Partnership meeting in Bismarck, North Dakota; particular student surveys and teacher logs were jointly examined on June 16 and 17, 2004, by educators and McREL researchers working with American Indian students.[2]

With regard to student assessments, Research Partnership members identified criteria for assessments of mathematics knowledge and skills, including that (1) items represent a balance between reasoning, conceptual understanding, and computation; (2) assessment items are aligned with curriculum content; and (3) reading demands are minimized as long as cognitive demand is not compromised. Released items from *NAEP Grade 4 Mathematics* and *MAEP (Michigan) Grade 4 Mathematics* meet the first and third criteria.

Teachers in Bismarck and Twin Buttes reviewed two surveys that asked students about their perceptions of their classroom learning environments. These two surveys were *My Class Inventory* (Fraser & Fisher, 1983) and the *Constructivist Learning Environment Survey* (Fraser,

[2] Educators included Jen Janecek, Director of United Tribes Technical College Rural Science Systemic Initiative; Teresa Delorme, Principal, and Denise Fulston, sixth-grade teacher, Pioneer Elementary School; Willa Incognito, sixth-grade teacher, Twin Buttes Elementary School.

1998). The teachers' review concluded that important features of participatory learning environments were covered but that students would need several of the terms clarified. The reviewers suggested that researchers first ask students' teachers to identify potentially confusing terms in the surveys and to jointly develop definitions. Also, reviewers suggested administering the surveys as a structured group interview with two or three students at a time.

Teachers also reviewed the *Mathematics Daily Log* (RAND #011003) and agreed that teachers would be willing and able to complete such a log daily. Recommendations included clarifying certain terms with concrete examples and adding a request to list mathematics vocabulary used.

PHASE III RESEARCH DESIGN

The purpose of the Phase III study is to better understand connections between teaching practices and mathematics achievement for American Indian students in North Dakota. These students represent a substantial subgroup attending both tribal and public schools about whom there is concern but little research-based evidence to guide efforts at improvement. The Phase III study is designed to examine the implementation of, and outcomes associated with, an approach to teaching mathematics valued by professional educators participating in this Research Partnership, specifically, Cognitively Guided Instruction. A mixed methods comparative case study will be used for the Phase III study.

This study will extend prior research by including assessment of student achievement at its core and operationalizing ideas about why and how mathematics talk and participatory learning environments appear to be important dimensions of effective pedagogy for American Indian students. In addition to measuring student achievement and documenting mathematics talk and participatory learning, the study design includes procedures for addressing rival explanations. Sampling procedures involve identifying both a CGI site and a comparison site not using CGI but with similar student population demographics. Data collection procedures address rival explanations, including student, school, and community background factors and instructional practices that are not typically characteristic of CGI.

OVERALL STRATEGY AND RATIONALE

The overall strategy of Phase III is to develop "thorough understanding" (Stake, 1995) through a case study. For the purposes of this study, the central phenomenon, mathematics achievement, will be generally defined as progress toward or proficiency in fourth-grade mathematics. Similarly, an American Indian fourth-grade student generally will be defined as a fourth grader enrolled in a tribal or public school in North Dakota and identified as a member of a recognized tribe or Indian community. Our purpose is to tell the stories of teachers whose students are advancing toward or beyond proficiency in meaningful mathematics standards so that others can imagine a role for themselves in similar types of experiences. This project complements experimental, *what works* research in culturally based education (i.e., Yapp, 2004) by using a mixed methods case study design to address *what is* and *what could be.* Moreover, the present study sample complements the study sample proposed in Yapp's (2004) research, which includes schools where at least half of the student population is American Indian. In the present

study, the sample will include schools where less than half of the student population is American Indian.

Research Questions

The overarching research question for this study is "What are the primary ways in which American Indian students succeed in mathematics in North Dakota grade four classrooms and schools?"

Related sub-questions include the following:

a. To what extent are there systematic relationships between patterns of teacher questioning and student mathematics achievement?

b. To what extent are there systematic relationships between indicators of a participatory learning environments and student mathematics achievement?

c. To what extent and in what manner are teacher questioning strategies and indicators of a participatory learning environment supported by or in conflict with standards-based policies and practices?

RESEARCH METHODS

A comparative case study design including mixed methods will be used, including quantitative analyses of relationships between student achievement and key pedagogical variables and practices and student background factors. Site visits involving interviews, observations, and document review will be used, and qualitative data will be analyzed using constant comparative methods.

Sampling Frame

A purposive sampling strategy will be used to identify two study sites and two to four classrooms. Initial site selection criteria, used to ensure that sites are representative of schools serving American Indian students in North Dakota, are (1) grade levels from Pre-K to six, (2) at least 10 percent of the student population is American Indian, and (3) an FRL rate of 40 percent or more. One site will be using CGI for teaching mathematics; a comparison site will not be using CGI but will have comparable demographic characteristics and a record of relatively high performance for American Indian students as a subgroup.

Teachers and students in all fourth-grade classrooms at the study sites will make up the sample of teachers and students. Three target students in each classroom will be identified to obtain student-level data on participation in instructional activities and conversations and achievement. These students will be American Indian students identified by the classroom teacher as low, medium, and high achievers.

DATA COLLECTION AND INSTRUMENTATION

Data will be collected to measure key variables and address rival explanations. Key variables as indicated in the research questions are mathematics achievement, level of cognitive demand in teacher questioning, and indicators of participatory learning environments. Rival explanations involve demographic and context factors and alternative theoretical perspectives.

Mathematics Achievement

To measure student achievement, mathematics subtest(s) of an achievement test will be administered to students in study classrooms. Two achievement tests, not used in the North Dakota State Assessment system, are being considered for this purpose: *Wide Range Achievement Test-Expanded (WRAT-E) Group Form* (Robertson, 2003) and *Iowa Tests of Basic Skills® (ITBS)®* (Hoover, Dunbar, & Frisbie, 2001). One of these tests will be selected for use based on meeting three of four criteria: (1) aligned with North Dakota fourth-grade mathematics standards and benchmarks, (2) scoring turn-around time fits project timeline, (3) American Indian students are represented in the norming sample, and (4) adequate reliability and validity. If available and psychometrically sound, both criterion-referenced and norm-referenced scores will be used as measures of achievement.

Teacher Questioning and Classroom Mathematics Talk

A teacher survey, a daily activity log, and classroom observations will be used to obtain data on teacher questioning and conversations with students. Data sources, variables, and scores for each of these tools are presented in Table 3.

Table 3. Data Collection for Teacher Questioning and Interactions

<table>
<tr><th>Tool</th><th>Data Sources</th><th>Variables</th><th>Scores and other Data</th></tr>
<tr><td>Teacher Survey of Practices</td><td>Teacher self-assessment in response to Likert-type and open-ended questions</td><td rowspan="3">Level of cognitive demand
Encouraging talk
Developing vocabulary
Corrective feedback
Expectations (high or low)</td><td rowspan="3">Extent to which press for justification, explanation, and meaning is sustained

Frequency of instances of different categories of talk format (e.g., initiation, response, evaluation [IRE]; revoicing or restating; developing common understanding of each other’s experiences)</td></tr>
<tr><td>Daily Activity Log</td><td>Teacher self-report</td></tr>
<tr><td>Observation Protocol</td><td>Researcher field notes from interviews and classroom observations</td></tr>
</table>

Participatory Learning Environments

My Class Inventory (MCI) (Fraser & Fisher, 1983) and *Constructivist Learning Environment Survey* (Fraser, 1998) will be used in a structured interview format with student participants in study classrooms. Both have adequate reliability and evidence of validity (Fraser & Fisher, 1983; Fraser, 1998). Prior elementary school research has shown significant positive

correlations between MCI ratings and the extent to which teachers create a climate of acceptance and active participation in their classrooms (Apthorp, 2000).

Student Background

Student's prior knowledge in mathematics will be measured by performance on the most recent North Dakota grade-level assessment in mathematics (administered annually in the fall). Student demographic data (gender, years in present school, eligibility for free or reduced-lunch lunch, American Indian/non-American Indian) will be collected from school records. The extent to which students identify themselves as American Indian will be determined by asking students, "Do you see yourself as American Indian"? using the scale "not at all" (0), "a little" (1), "some" (2), and "a lot" (3) (Zimmerman et al., 1995, p. 209).

School and Community Context

Data on school-level standards-based policies and practices will be collected through document review and interviews with school administrators and teachers and community elders. Documents and information to be gathered include school and district curricula, pacing charts, content standards and benchmarks, and definitions of proficiency levels. Information on community context will include frequency of activities of American Indian families in the community, such as attending Pow Wows, seasonal feasts, and naming ceremonies.

Rival Instructional Factors

Data will be collected related to the extent to which teaching is structured. For this purpose, a set of survey items used to measure structured teaching in the McREL Teacher Survey of Policies and Practices will be used (see Apthorp et al., 2004). Additionally, the classroom observation protocol will include recording whether or not the three target students are engaged in academic talk (e.g., answering or asking academic questions), task management (e.g., looking for or setting up materials, asking for clarification on task or activity directions), or non-academic or task management behaviors (e.g., looking around, playing or talking inappropriately, being disruptive).

DATA ANALYSIS

To answer the research questions, several stages of data analysis will be used. For the qualitative data, categories of teacher questioning and patterns of student participation in learning and in mathematics talk will be identified during data collection. As new data are collected, they will be compared to the categories and patterns, and the two steps will be repeated until all data fit into categories and patterns. Second, conditional matrices, chronologies, and other forms of tabular presentations of data will be used to examine possible patterns or relationships between practices and student achievement. Finally, a cross-case analysis will be conducted to further develop an interpretation of the ways in which teaching practice and student achievement are related.

Using the achievement data, class averages, American Indian student averages, and non-American Indian student averages will be computed for each classroom. We will conduct a linear

regression between prior achievement and current achievement and identify/count students (American Indian and non-American Indian) who perform above predicted levels. Finally, we will conduct comparative analyses across classrooms and student groups using teacher and classroom practice data to determine if evidence suggests connections between practices and achievement above predicted levels.

VERIFICATION

Four procedures will be used to establish credibility of findings and interpretations (Creswell, 1998). First, multiple and different sources of data, methods, and perspectives will be used to corroborate or refine interpretation of data from any one single source. Second, active searching and consideration of negative or disconfirming evidence will be conducted and initial hypotheses revised until all cases, including exceptions and outliers, are accounted for. Third, member checks will be conducted; this will include having participant teachers and others on-site in the study schools review the accuracy of data categories and interpretations. Fourth, members of the Research Partnership will be involved in peer review and/or debriefing periodically throughout the study and formally for review of the first draft of the report of findings.

The project timeline involves four overlapping stages of work, as reviewed in Table 4. During the first two months (October and November), study sites and participants will be selected and prepared and instrumentation finalized. Data will be collected and analyzed during the following months. Draft and final reports will then be written; the final report will be completed by June 15, 2005. Subsequently, McREL will utilize the knowledge gained from the project in a product for teachers, such as a teacher's guide and/or case examples of how to implement standards-based practices in mathematics instruction for culturally diverse groups of students.

Table 4. Project Timeline

Task	Activities
October 4 to November 30, 2004	
Site Selection and Preparation	Review site selection with Research Partners.
	Gather background info on study sites.
	Invite site and classroom teacher participation.
	Assure protection of rights of human subjects and tribal sovereignty.
Finalize Instrumentation	Review mathematics content, psychometric and norming properties, and scoring turn-around time of achievement tests; select/purchase one (ITBS and WRAT-E Group).
	Adapt MCI and CLES for diad or triad interview.
	Adapt RAND daily log and McREL Teacher Survey of Policies and Practices.
	Finalize interview and document review protocols for gathering information on standards-based policies and practices.
	Finalize classroom observation protocol.
	Define variable measures.

Task	Activities
December 2004 to February 2005	
Data Collection	Teachers complete daily log
	Site visits to establish Memoranda of Agreement and collect student and school-level data
	Site visits to interview and survey students and teachers; collect student work, lesson artifacts; observe classrooms; recruit and train achievement test examiners
	Test examiners administer student achievement tests
February, March, and April 2005	
Data Analysis	Descriptive summaries of (1) teacher daily log, (2) classroom observations, (3) school context and standards-based policies and practices, (4) student perceptions of learning environment, and (5) student achievement
	Verification/triangulation – (1) with (2), (1) with (4), (2) with (4) above
	Code data for patterns and emphases in practices.
	Examine data for relationships between practices and student achievement.
March, April, and June 2005	
Report Writing	Write appendices: (A) Daily log summary, (B) Student perceptions summary, C) Classroom observations summary.
	Draft report answering research questions (due to external reviewers, 5/15/05).
	Finalize report (due June 15, 2005).

ANTICIPATED BENEFITS AND OUTCOMES

This research is being designed in part in response to the needs of educators and policymakers in the Central Region states for evidence-based knowledge about effective practices and achievement outcomes for American Indian students in elementary schools. The process of designing the study, conducting the study in North Dakota schools, and interpreting findings through the Research Partnership offers multiple opportunities for professional development. As members of this partnership, American Indian educators are involved in clearly communicating valued education goals, operationalizing progress toward goals through instrument development, identifying and creating representative research samples, and interpreting and using findings appropriately. In addition, it is anticipated that this project will result in rich, case-based knowledge about implementing standards in mathematics instruction for culturally diverse groups of students.

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APPENDIX A

Lists of Research Partnership and Advisory Panel Members

Research Partnership

Rose-Marie Davis, School Improvement Specialist, Turtle Mountain Agency, ND
Teresa Delorme, Principal, Pioneer Elementary School, Bismarck, ND
Lori Gibson, Math Staff Developer, Bismarck Public Schools, ND
Jean M. Hall, Principal, Edwin Loe Elementary School, New Town Public School District, ND
Kathy Jo Henry, Instructional Coordinator, Ojibwa Indian School, Belcourt, ND
Elaine Incognito, Principal, Twin Buttes School, Three Affiliated Tribes, ND
Willa Incognito, Sixth-Grade Teacher, Twin Buttes School, Three Affiliated Tribes, ND
Jen Janecek, UTRSI Director, United Technical Tribal College, Bismarck, ND
Ellen Knudson, Math Staff Developer, Bismarck Public Schools, ND
Gene La Fromboise, Superintendent, Standing Rock Community Schools, ND

Advisory Panel

Donna Dehyle, Ph.D., University of Utah
Gerald R. Fast, Ph.D., University of Wisconsin-Oshkosh
Cheryl M. Kulas, Director, North Dakota Indian Affairs Commission

Minority Interns

2002 - Nicole Bowman, Owner Bowman Consulting, Wisconsin
2003 – Teresa Delorme, Pioneer Elementary School, Bismarck, North Dakota
2003 - Gene La Fromboise, Turtle Mountain RSI, Belcourt, North Dakota
2004 – RunningHorse Livingston, Middleton, Wisconsin

Visiting Scholar

2004 – Judith Hankes, Ph.D., University of Wisconsin-Oshkosh

APPENDIX B

Mathematics Curriculum Materials Used in North Dakota Schools Serving Native American Students

Textbook and Approach	Schools
Houghton Mifflin	Twin Buttes Day School, Halliday White Shield School, Roseglen
Accelerated Math	Twin Buttes Elementary, Halliday Standing Rock Schools, Fort Yates
Saxon	Dunseith Elementary, Dunseith Ojibwe Indian School, Belcourt White Shield School, Roseglen Fort Lincoln Elementary, Mandan
Everyday Math Developing Mathematical Ideas (DMI)	Bismarck Public Schools
SRA	Dunseith Indian Day School, Dunseith
Others: Cognitively Guided Instruction Investigations Scott Forseman *Changing Faces of Mathematics: Perspectives on Indigenous Peoples of North America* (NCTM, 2002)	

Note: Information for this exhibit was gathered from a survey of teachers (including many Special Education teachers) who attended a regional Bureau of Indian Affairs professional development session held on May 2, 2003. This information has been supplemented by information provided by Mr. Gene LaFromboise and Dr. Teresa Delorme 11/11/03.