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Improving Elementary American Indian Students' Math Achievement with Inquiry-Based Mathematics and Games

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In This Issue

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Jamalee Stone and Edmund Hamann

Project Inquiry-Based Mathematics was a National Science Foundation Math-Science Partnership implemented in a Great Plains city school district with a significant K-12 Native American population. One goal of the project was to reduce the achievement gap between Native American and non-Native students enrolled in district. This gap reduction was to be achieved using inquiry-based mathematics curricula along with cognitively guided instructional strategies, particularly at the elementary level. This study focuses on whether inquiry-based mathematics strategies were consistently implemented in three fifth-grade classrooms at K-5 elementary schools with significant Native American student populations. Test results of Native American students at these three schools are compared with the test results of Native American fifth grade students at a fourth school considered by district leadership to be an exemplar of inquiry-based math instruction. Possible reasons for the performance disparity are explored.

Introduction

Over a decade ago, the National Council of Teachers of Mathematics (NCTM) *Principles and Standards for School Mathematics* (2000) positioned *equity* at the forefront of the principles for school mathematics. This principle was seemingly unequivocal, as the document stated:

> Excellence in mathematics education requires equity — high expectations and strong support for *all* students....All students, regardless of their personal characteristics, backgrounds, or physical challenges, must have opportunities to study — and support to learn — mathematics. (NCTM, 2000, p. 12)

One reason for this stance was that well-documented examples provide evidence that all children, including those who have been traditionally underserved, can learn mathematics when they have access to high-quality instructional programs that support their learning (e.g., Gutstein, 2003; Lipman & Gutstein, 2001; Schoenfeld, 2002). Another reason was fairness and social justice.

Although there have been striking examples of success (e.g., Hankes, 1998; Lipka et al., 2005, 2007), American Indians are among the populations that too often have been poorly served by math education. For that reason, mathematics education strategies that seem particularly effective with American Indian learners and that close achievement gaps are of great interest.

In this article we examine Project Inquiry-Based Math (Project IBM) in Great Plains City schools (the school district where this program was implemented; all names are pseudonyms). We also explore the changes and continuities of classroom culture in four elementary schools through teacher vignettes. We discuss fifth grade achievement data, particularly the comparative achievement patterns of American Indian and White students, and consider what may have been reasons for why one of the four studied schools outperformed the other three.

Project IBM, a National Science Foundation (NSF)-funded Math and Science Partnership, was implemented in a Great Plains city with a significant American Indian population. The project was implemented with the intent of improving *all* students' mathematical performance, with a primary and explicit objective to reduce the achievement gap between American Indian and non-American Indian students in the school district.

Consistent with this journal's goal to improve Native education through knowledge generation and transmission to classrooms and other educational settings, our research chronicles Project IBM implementation at four elementary schools with a significant American Indian student population in one Great Plains city (including one that was considered an exemplar of inquiry-based mathematics implementation by the school district) with particular attention to how American Indian students fared under its auspices.

Aware that American Indian students are no more homogenous than any other student demographic category and that crafting an experimental design was not viable for other reasons as well, we explore how inquiry-based math (a category that encompasses Project IBM) worked with American Indian students, as described by teachers and parents, as well as by looking at student outcome data. Before we can do this, however, we need to explain where Project IBM was implemented and why inquiry-based math would, per theory, be a viable strategy for reaching American Indian students. In all of this we need to remember Erickson and Gutiérrez's (2002) caution to study what was implemented, rather than what *was supposed to be* implemented, a caveat that proves telling for explaining one school's greater success than the other three. Because site visits and fieldwork were conducted strictly by the lead author (as part of dissertation research supervised by the second author), in the fourth section of this chapter the use of "I" is frequent and refers to the lead author.

Background

New curriculum implementation, like any other activity at schools, happens in real places and per certain local logics. It follows then that to consider Project IBM implementation with American Indian students first requires giving some description of the Great Plains City schools, including elementary math achievement and teacher demographics. We then explain why a curriculum suggested through Project IBM might work better for American Indian children, before explaining this project's research methodology and empirical inquiry.

Great Plains City — The Research Site

The school district studied in this investigation enrolled approximately 13,000 students, making it one of the largest in the state. The district included 15 elementary schools, five middle schools, and three high schools, and employed approximately 500 teachers of mathematics (including elementary and special education teachers who teach multiple content areas). At the fifth grade level, 36 percent of district students qualified for free or reduced-price lunch and 22 percent were non-White (17 percent American Indian, 5 percent "other" non-White groups). The school district enrolled the largest off-reservation population of American Indian students in the state.

In 2002, when "No Child Left Behind" implementation catapulted disaggregated achievement data to a new level of scrutiny, 49 percent of fifth grade students enrolled in the school district scored proficient or above (6 percent advanced, 43 percent proficient) on the state assessment in math. By 2010, the percentage had risen to 75 percent (20 percent advanced, 55 percent proficient) In 2003, the achievement gap between non-American Indian and American Indian fifth grade students at the advanced or proficient level was 37 percent. By 2010, the achievement gap at the advanced or proficient level had decreased to 30 percent In 2010, 81 percent of White fifth grade students were denoted as proficient or advanced while 51 percent of American Indian students scored proficient or above (retrieved from anonymous State Department of Education data, March 1, 2011).

Reflecting improved instruction, better test preparation, consequences of one-time recalibration of the state's definition of proficient, or likely some mix of all three, during the seven-year period from 2003-2010, both groups improved significantly, with the American Indian students improving from 18 percent rated as advanced or proficient in 2003 to 51 percent advanced or proficient in 2010, a 183.3 percent increase (see Table 1).

Looking at the advanced category only, in 2003, 7 percent of non-American Indian students scored at that level and 1 percent of Americans Indians reached that level. In 2010, both groups posted gains from their 2003 percentages. In 2010, 23 percent of non-American Indian students scored at the advanced level and 5 percent of Americans Indians scored at the same level. This indication of student achievement increases for both groups is promising. If we look at the "meets and

Table1. Percentage of Great Plains City fifth grade math students proficient or above (2003-2010)

A=Advanced P=Proficient	2003	2010	Percent Increase or Decrease
All Students	49 6 A, 43 P	75 20 A, 55 P	53
American Indian	18 1 A, 17 P	51 5 A 46 P	183
White	55 7 A, 42 P	81 23 A 53 P	58
Achievement Gap	37	30	-19

Source: Great Plains City's State Department of Education, 2011

exceeds proficiency" category, the achievement gap was reduced from 2003 to 2010 while scores for both groups increased. However, highlighting how vexing it can be to narrow achievement gaps, if we look just at the advanced achievers, again both White and American Indian students fared better in 2010, compared to 2003, but the achievement gap widened from 6 percentage points to 18.

Cultural Familiarity and Teacher Effectiveness

In Great Plains City, as elsewhere (Howard, 2003), most elementary school teachers during the study period were White middle-class females. At the four elementary schools studied, 90 percent were White, and many in the remaining 10 percent were not necessarily familiar with American Indian cultures. It follows that the backgrounds and lived experiences of the large majority of elementary teachers at the school district were different from their American Indian students. We are not suggesting that American Indian students cannot learn from White teachers, but it does seem hazardous to assume that the White teacher/American Indian student learning interface was as likely to be successful as the White/White interface absent overt efforts to assure this was so. Research supports the notion that American Indian children, as children of all ethnicities, fare better when they have teachers who look like them and share their culture and languages (Vandergriff, 2006, p. 1).

Like a long list of others writing in the cultural mismatch tradition (Erickson, 1987), Downey and Cobbs (2007) assert that majority culture teachers may fail to understand minority culture students' perspectives, cultural values, ways of knowing, and learning needs, creating a mismatch between the perspectives, values, and understandings of students and their families with those promoted by the routine practice of schooling. Sadly, few teachers recognize the knowledge and learning strategies that many American Indian students bring with them to school (Nelson-Barber & Estrin, 1995).

Starnes (2006) claims that solid teaching skills, good intentions, hard work, and caring for kids are not enough to cross the divide when teachers and students come from different cultural traditions. Others have described the general invisibility of "Whiteness" to many Whites (e.g., Delpit, 1988, 1995; Sleeter, 2001), pointing out that it is hard to compensate for limitations or particularities of one's cultural frame of reference if the frame itself remains unrecognized. White teachers do not always recognize that a gap can exist between their students' needs and traditionally accepted curricula and methodology. Also problematic, when they do recognize the difference, too often the difference is constructed as a unilateral deficit on the student's part rather than a two-sided mismatch for which the instructor is also responsible (Oakes, 1985).

Lomawaima (2000) has declared that the need for quality research in American Indian education is pressing. Fortunately, despite a paucity of funding and coordinating efforts, a research base has emerged to address American Indian students' learning styles and generating evidence of what works to improve the academic performance of Indigenous students (e.g., Demmert, 2001; Demmert & Towner, 2003). Still, Demmert (2005) contends that our ability to understand the problems faced by American Indian students in today's educational system is severely limited by the lack of information regarding the education of this particular sector of society. According to Lipka (1991), whose career has focused on developing culturally relevant concept-based mathematics, for teachers to effectively instruct students of color they must possess an in-depth understanding of the content area as it is used and known within a culture and be familiar with culturally-inflected communication styles and values. While there is not just one way to reach American Indian students, abundant research shows that there are patterns or strategies that are more culturally responsive and successful. Usually, a culturally responsive approach in education requires a shift in teaching methods, curricular materials, teacher dispositions, and school-community relations (Brayboy & Castagno, 2009).

What American Indian schooling should accomplish has been controversial since the birth of the United States. Some non-Indigenous actors such as Lewis Meriam and John Collier advocated for better American Indian education (Lomawaima & McCarty, 2006), although their efforts were sometimes paternalistic — thus better intended than actually achieved. In general, assimilation rather than acculturation has proven to be the American school's dominant and more problematic goal for American Indian students (Szasz, 1999).

Distinguishing *assimilation* as efforts at unilateral cultural change from existing understandings to those of the dominant group (Grey, 1991) from *acculturation* in which gaining understandings of a new culture is not seen as jeopardizing existing cultural knowledge or affiliations (Gibson, 1988), acculturation seems like a more constructivist and affirming orientation. The learning emphasized in cognitively guided instruction (CGI) is more acculturative than assimilative.

Inquiry-Based and Cognitively Guided Instruction

Project IBM began in 2003 and focused upon adopting inquiry-based mathematics materials in Great Plains City's K-12 public schools. District-wide interventions included using building-based "math teacher leaders" and making available graduate-level courses for teachers that focused on deepening teacher content knowledge and increasing understanding of students' mathematical thinking. Thus all teachers had access to coaches while only some enrolled in graduate course work. The teacher leaders provided job-embedded professional development and support at the classroom level. Teacher leaders met with their assigned classroom teachers on a weekly basis as a group. They orchestrated classroom teachers' transition from a teacher-centered delivery method to a teaching method that focused more upon student learning. A component of the inquiry-based implementation strategy at the elementary level was the use of CGI and the K-5 elementary math curriculum *Investigations in Number, Data, and Space* (Technology Education Research Center [TERC], 2011), which is well aligned with the CGI philosophy.

CGI was developed by Thomas Carpenter and Elisabeth Fennema through a research project at the University of Wisconsin-Madison in the early 1990s. CGI itself is neither a curriculum nor instructional design. Rather, the primary goal of CGI is to help teachers acquire knowledge of children's mathematical thinking and then to consider how teachers can use children's knowledge to design and implement instruction (Carpenter et al., 1998, 1999; Hiebert et al., 1997). A large body of research indicates the benefits of conceptual teaching strategies as part of an inquiry-based approach such as CGI (Carpenter et al., 1999; Hiebert et al., 1997; Kazemi & Stipek, 2001).

Judith Hankes was a doctoral student at the University of Wisconsin-Oshkosh during CGI's development; since then, she has been at the forefront of research concerning the relationship between CGI and Native American pedagogy as she wrote her dissertation on the topic (Hankes, 1998). With CGI an essential component of Project IBM, Hankes's work becomes particularly relevant to our case.

After her caveat that there is tremendous diversity within and between various Native American groups but also some notable consistencies, Hankes (1998) found that both CGI and what she called "Native American pedagogy" viewed the teacher as a facilitator who, to be most effective, acts indirectly rather than providing direct instruction to students. Both CGI and Native American pedagogy utilize problem solving, or sense making — that is, students are allowed to solve problems using methods that make sense to them personally and with tools with which they feel comfortable. Problems are based upon the life experiences of the students; problem-solving calls for cooperation rather than competition and is time-generous rather than time-driven. Students receive ample time to problem solve and think ideas through rather than being rushed to arrive at a final solution (see Table 2).

Table 2. Correspondence between American Indian pedagogy and cognitively guided instruction (Hankes, 1998, pp. 22-23)

Native American Culture-based Instruction Principle #1	CGI Example
Teacher as facilitator — indirect rather than direct instruction.	The teacher presents problems and trusts students to solve them. Students are encouraged to construct their own understanding as well as instruct one another.
Native American Culture-based Instruction Principle #2	**CGI Example**
Problem solving that is sense-making (each student is allowed to solve problems in any way that makes sense to that student).	Students are allowed to use tools in any way that makes sense to them, e.g., manipulating concrete objects, drawing, invented procedures, etc.
Native American Culture-based Instruction Principle #3	**CGI Example**
Problems based on the cultures and lived experiences of the students.	Problems are based on shared classroom experience, e.g. a story, a science unit, students' lives.
Native American Culture-based Instruction Principle #4	**CGI Example**
Cooperation rather than competition.	Children are allowed to work in teams or individually and are asked to share their solutions strategies. Each student's thinking is accepted and respected.
Native American Culture-based Instruction Principle #5	**CGI Example**
Time-generous rather than time-driven instruction.	Class time is spent solving several complex problems with understanding. Enough time is granted to discuss problems thoroughly.

Recently, Midcontinent Research for Education and Learning (McREL) (2005) conducted an exploratory study on the elementary math curricula in four Great Plains schools that served Lakota/Dakota students. They found that students who were engaged with CGI lessons may have had more opportunities to practice and develop mathematical reasoning. McREL recommended further studies on cooperativeness in classroom environments and how teachers effectively use verbal interactions to advance students' mathematical knowledge and skills (p. 38), which makes our research a direct response to this request.

Investigations in Number, Data, and Space

Although CGI is not a curriculum, curricular materials have been developed that embrace the CGI philosophy, such as *Investigations in Number, Data, and Space. Investigations* is a K-5 mathematics curriculum, developed by TERC. *Investigations* has also been funded by the NSF. As an inquiry-based mathematics curriculum, it is designed to help *all* children understand fundamental ideas of numbers and operations, geometry, data, measurement, and early algebra. *Investigations* lends itself to adaptation and cultural responsiveness because inquiry-based instruction allows the learner and teacher to adapt the teaching process in ways that make most sense to the learner.

Rochelle Gutierrez (2008), who studies equity and mathematics education, explained, "the goal is not to replace traditional mathematics with a predefined 'culturally relevant mathematics' in an essentialist way, but rather to strike a balance between opportunities to reflect on oneself and others as part of the mathematics learning experience" (p. 2). Indeed the larger point of culturally relevant, inquiry-oriented instruction is that the particulars of what constitutes cultural relevance will vary within groups, among groups, and over time, but responsiveness to the learner will be constant.

Applying these findings to the context of the school district being studied, the mismatch between mainly White female teachers and the large enrollment of American Indian students required overt efforts at bridging differences. Otherwise that difference would likely prove deleterious for American Indian students, as illustrated by achievement gaps. Two of the questions that initially motivated the study were:

(1) What are the strategies that will be most effective in improving mathematics teaching and learning for American Indian children in the studied school district?
(2) Are these strategies consistently implemented in the elementary schools with a significant American Indian student population?

One component of the *Investigations* curriculum of particular importance to this field study is the use of games to support mathematical learning. The *Investigations* games provide students the opportunity to practice important mathematical concepts and skills and deepen their mathematical understanding and reasoning. The games encourage strategic mathematical thinking in students and provide opportunities for families to do math together (Investigations in Number, Data, and Space, 2008). Instead of completing worksheets for homework, students can engage in game playing with their family members (or others) as a means of practicing and learning mathematical skills.

We describe all of this to show that, through Project IBM and the adoption of the *Investigations* curriculum, it was plausible to consider the research sites as settings where math instruction was similar to practices successfully used with American Indian math learners elsewhere. Of course, a key issue was whether what was designed and what was possible matched what transpired.

Methodology

As one more short topic to consider before analyzing the math education efforts at four Great Plains City elementary schools, we need to recall Erickson and Gutierrez's (2002) caution, "A logically and empirically prior question to 'Did it work?' is 'What was the it?' — 'What was the treatment as actually delivered?'" (p. 21). This of course is the province of research design.

With Project IBM and *Investigations* implementation, district elementary teachers were supported by mathematics coaches who provided assistance and suggestions for teachers as they altered their practice to inquiry-based mathematics. It was hoped this would lead to improved achievement and narrowed achievement gaps. But before we can ask bluntly, "Did it?," this study also needs to account for what was actually happening with American Indian and other children in these classrooms.

So I (the lead author) ethnographically examined four fifth grade classrooms, one at each of four different elementary schools, during the 2008-2009 school year. I selected fifth grade because the students in that grade had experienced inquiry-based mathematics curriculum and instruction for most of their elementary years in the K-12 school district. If any age level showed "effects" of the value of this mathematics education strategy, it was likeliest to be this group. In my study, implementation at three elementary schools with high American Indian student enrollments (Lincoln, Washington, and Jefferson) was compared with a fourth elementary school (Roosevelt) that had a lower American Indian student population and was considered an exemplar of inquiry-based mathematics implementation by the school district. (No elementary schools in the district were named after American Indians, but several were named after European Americans, thus the pseudonyms chosen for the study were consistent with the district's naming pattern.)

I was interested in determining if there was consistency in implementing the *Investigations* curriculum in a manner that was culturally responsive at the three elementary schools with a significant American Indian population, and whether there was a strategy at the fourth school (Roosevelt) with a lower American Indian population that could account for the high achievement for *both* American Indian and non-American Indian students in that school.

Education policy implementation scholars (e.g., Hamann & Rosen, 2011) have explained that any policy contains at least three constituent pieces — a problem diagnosis, a strategy for response to the identified problem, and a sense of what should be. In the case of *Investigations* implementation in Great Plains City schools, presumably there was a diagnosis that existing math achievement was inadequate (from the excellence and/or equity lenses); *Investigations* was seen as a solution to this problem, and higher achievement was imagined as what should be.

This being the macro-conceptualization does not mean that it matched the way each prospective implementer understood his/her task. So an ethnographic case study approach (similar to Lipka et al., 2005) was used to observe how teachers made sense of enacting an inquiry-based elementary mathematics curriculum. One question specifically considered was: Was helping American Indian students to achieve a conscious part of teachers' conceptualization of the task? Data were triangulated through the use of classroom observations, teacher and teacher-leader interviews, and a teacher-belief survey. From these data, I hoped to determine how these teachers considered students' thinking and academic (mathematics) capabilities. I wanted to determine what type of interactions occurred between the teachers I studied and their students. According to Delpit (1995), teachers who respect cultural differences are more apt to believe that students from non-dominant groups are capable learners. Was there evidence of this in Great Plains City?

Lincoln is located in an older, mostly low-income section of the city and, at the time of the study, enrolled 565 students, with 55 percent American Indian; 75 percent of all students were classified as economically disadvantaged and qualified for free and reduced lunch. Three teacher leaders (two American Indian and one White) worked at Lincoln. Jefferson enrolled 270 students, with 47 percent American Indian; 71 percent of all students were classified as economically disadvantaged and qualified for free and reduced lunch; 17 percent of all students were classified as "homeless migrant," meaning they did not live consistently with their parents (instead with grandparents, aunts and uncles, or foster care). One teacher leader (White) worked at Jefferson. Washington served 413 students, 63 percent of whom were American Indian; 86 percent of all students were classified as economically disadvantaged; here too 17 percent of all students were classified as "homeless migrant." Two teacher leaders (White) worked at Washington. Roosevelt enrolled 400 students with 24 percent American Indian and 56 percent of all students were classified as economically disadvantaged and qualified for free and reduced lunch. One teacher leader (White) worked at Roosevelt.

I observed one fifth grade teacher at each of these four elementary schools in Great Plains City School District throughout the fall 2008 semester. Hannah was White and the fifth grade teacher observed at Lincoln. Emma was White and the fifth grade teacher from Jefferson. Julian was American Indian and the only male teacher-participant and the fifth grade teacher from Washington. Melissa was White and the fifth grade teacher observed at Roosevelt. The selection of schools was purposeful (based on American Indian enrollment and math achievement), but the selection of which teacher to observe at each school varied. Julian was a former high school student of mine, and I wished to observe his classroom for that reason. The other three teachers were selected by their building principals. At the time of the observations, two of the four teachers had been involved with the Project IBM professional development on CGI, and they all worked with their teacher leaders (who were trained in CGI) on a weekly basis. There were a total of ten fifth grade classrooms in the four elementary schools studied; thus the four observed classrooms constituted 40 percent of the fifth grade at those schools and 10 percent of the fifth grade in the entire district.

Classroom Observations

Hannah

Hannah lived most of her life on the East Coast. Her undergraduate degree was in sociology and she earned her master's degree in elementary education and teaching certificate concurrently. She moved to the Great Plains City school district (and Lincoln Elementary) eight years prior to observation and served as a fifth-grade literacy teacher during her first six years. Hannah was in her second year as a fifth-grade classroom teacher at Lincoln.

When I first observed Hannah's classroom, the desks were in traditional rows. She quickly explained that the desks had been in groups at the beginning of the year, but the students needed some "alone" time to work on mathematics. After Hannah's initial introduction of the lesson of the day, students were allowed to move about the room, to find a partner and a different area to work than their assigned seats. When I made my last observation in fall 2008, the desks had been moved back into groups.

Hannah developed problems (to accompany *Investigations* lessons) for children to solve that she thought were relevant to their experiences; the problems elicited students' thinking and she provided them with freedom to choose how they were to arrive at a solution. One problem Hannah had written on the whiteboard and asked the children to solve was, "You and your friend have made $14.00 at your lemonade stand and you want to donate some money equally to 4 animal shelters. How much would each shelter get?" She followed this inquiry with the directive, "You will work with a partner but both people need to write and solve the problem."

Hannah reminded students that they could use manipulatives (tiles, graph paper, etc.) to help them solve the problem. Students immediately sprang into action and moved around the room to find the partner they wanted to work with. Once a partner was found, the pair moved to an area in the room that was comfortable for them to work. Students appeared familiar with this routine and found a partner to work with efficiently. Some students pulled their desks together, others chose to work in open areas on the floor, while other move to the countertops available on the side of the room. One American Indian student was allowed to work by himself. Hannah later told me that he preferred to solve problems on his own but could work cooperatively.

Emma

Emma was born and raised in the state and attended a state university, majoring in elementary education. She was in her fourth year of teaching, but this was her first year teaching at Jefferson. She had resigned her position at another school in the district to move with her fiancé. Her fiancé was not transferred and her previous position had been filled; thus she filled a vacancy at Jefferson.

Emma's classroom was arranged so desks were adjacent to each other, with all students having at least one classmate in close proximity. When it was time to work with a partner, Emma allowed students to find a partner and a comfortable area to work, which was similar to Hannah's instructions. During one observation, Emma told the students to get out their notebooks and write the following problem in their notebook. Emma said, "There are 252 fourth and fifth graders. They have to be put on 21 equal teams. How many people will be on a team?" I walked around the room to observe the strategies that students used to solve the problem.

One student had written:

252÷21	210÷21=10	
	42÷21= 2	
	252	12 There are 12 teams.

The student had used the "friendly number" 10 to help him solve the problem. (Numbers that end in 0 are considered friendly numbers.)

A group of American Indian girls wrote:

21 x ______	= 252
21 x 10	= 210
21 x 1	= 21
21 x 1	= 21

I asked one of the girls to explain to me what she did. She told me, "I wrote 21 X ______ = 252." Emma asked her why she chose 10 and the girl said that she was not sure. (Ten was used because it is a "friendly" number.) I later found out that the girl who wasn't sure why she had used 10 had recently moved into the district and was unfamiliar with inquiry-based mathematics and its emphasis on knowing not just *what* to do but *why* you are doing what you are doing.

An American Indian boy began to make tally marks to solve the problem. Emma said to him, "Whoa, this isn't going to be efficient for us. Isn't counting by 21 faster than tally marks?" (She told him what to do rather than letting him think of another way himself.) After thinking about what Emma said, the boy began to count by groups of 21. Although it is not "wrong" to tell a student how to approach a problem, with inquiry-based mathematics, the use of effective questioning to guide students to a solution strategy is recommended (PBS TeacherLine, n.d.).

An American Indian girl from the group mentioned earlier showed her strategy for solving the problem on the Promethean Board. Emma asked the class, "What should we call this strategy?" "Multiplying for division," she told the class, answering the question herself rather than waiting for one of her students to respond. Another girl said she used the "box strategy." Emma mentioned to the class that this was a great way to check answers, but that using the box strategy to solve a division problem was difficult. (Once a student has a divisor and quotient, he or she can multiply them together to see if the answer is the same as the dividend.)

Emma then directed the students to put away their notebooks and take out their math workbooks. She asked the students to "turn to page 53, put your name

on your paper, and work together" to solve the problem on the page. She told them to share their strategies and that they should be able to walk their partner through the steps to explain how the answer was reached. Emma told the students to find a partner and a place to work in the room. The students worked on the page-53 problem for the rest of the period. Although it was not the only approach she used, Emma demonstrated that she recognized the benefit of children solving problems in ways that made sense to them. Students were allowed some opportunity to discuss their solutions, and she listened to what students said about their mathematical thinking.

Julian

Julian lived in the Great Plains City area most of his life. He received a bachelor of arts degree in history and American Indian studies at a state college. He was hired by the Great Plains City school district as a Lakota cultural resource specialist. He was encouraged to become a teacher and enrolled in a career ladder program at a local tribal college where persons with an undergraduate degree could earn an elementary teaching degree. Julian had taught fifth grade at Washington for three years.

I observed division being practiced in Julian's classroom. He wrote the division problem 536÷38 on the board. He asked his class, "Write a story problem to go with the division problem. Solve the problem and give me the quotient." He said, "For example, I have 536 sheep. I want to give them to 38 people. How many sheep will each person get?"

Students worked by themselves at their respective tables to solve the problem. I asked one girl what her story problem was and she said, "I have 536 cherries and 38 cups. How many cherries will be in a cup?" I asked her why she chose to use the number 10. She told me that it was a friendly number, along with 5, 2, and 1: They were all friendly. I asked her what the "4" meant in her answer; she told me that there must have been four cherries left over.

Julian called the class back together and the girl I had visited with shared her work with the entire class. A second American Indian girl came to the front of the class and shared how she solved the problem. Julian asked her to explain what she did next. She said that she added the 10 + 2+2 to get 14 and 4 was the remainder between 536 and 532. Julian next gave students the problem 739÷26, again asking the students to come up with a story problem and to solve it. Julian circulated around the room and made the comment to his students, "It is good to see that most of you have moved away from the circles and tally marks."

In Julian's classroom, I noticed that students were first directed to work on a problem individually. After ten or 15 minutes, they were able to compare results with other students at their table, Julian, or his classroom aide and then their attention was directed to the front of the classroom where individuals shared their solution strategies for the problem to the entire class.

Melissa

Melissa had lived most of her life in the state except when she attended a liberal arts college in a neighboring state to earn her teaching degree. She was in her third year of teaching, all at Roosevelt and in the fifth-grade.

On one visit to Melissa's classroom, the students were working with division clusters using multiplication. Melissa had written on the whiteboard: 190÷2 = ___. She asked the students to think about how they would solve the problem. Then Melissa asked the students to copy in their notebook:

1. Find some factor pairs of 1,100.
2. Write about how you found each pair.

Melissa mentioned, "This is an individual activity. The most important part is how you write your explanation. Here is a little hint, you can think of 1,100 as 1,000 and 100 so if a number goes into 1,000 and it goes into 100 it will go into 1,100."

Students worked to find the factors of 1,100. Afterward there was whole group discussion of factors of 1,100. Some of the factor pairs and explanations included 2 x 550 and 5 x 220. The boy said that he knew five goes into any number that ends in a 5 or a 0. A second student inaccurately offered: 4 x 225. The student had doubled and halved 2 x 500. A girl offered 20 x 50 = 1,000 and 20 x 5 = 100; 20 x 55 would be a factor pair. Another boy offered 10 x 110. Melissa asked another boy, "Does 25 go into 1000?" The boy said that it does, "It goes 40 times." Melissa asked, "How many times does 25 go into 100?" The boy said, "It goes in four times." Melissa asked, "So what does that tell you?" The boy said, "44 times 25 equals 1,100." After that solution was given, another student offered 22 x 50 by halving and doubling. After the student finished Melissa told the students that she would be looking at the factor pairs and how the students explained them.

If It's Not Levels of Teacher Engagement

Each teacher was observed four different times during the fall 2008 semester. After my classroom observations were completed, I used the "Levels of Engagement with Children's Mathematical Thinking" rubric developed by Franke et al. (2001, p. 662) and suggested to me by Judith Hankes, to evaluate teacher beliefs and values with the presented inquiry-based lessons. The "Levels of Engagement" instrument was used to code the levels of student-student and teacher-student engagement witnessed by reading holistically the observation field notes and the teacher interviews, and searching for evidence that supported each benchmark on the rubric. Additionally I looked for evidence that indicated a teacher had not reached a particular benchmark and cited specific instances from the data. The analysis set up consideration of whether a pedagogical strategy that should be more responsive to American Indian students than traditional methods is at all commonplace and purposefully deployed in the observed classrooms. However, once I began my analysis of the observations I realized that my "Levels of Engagement" scores did little to indicate why the school district was disposed to point to Roosevelt as the strongest inquiry-based implementation site. All four teachers provided a variety of different problems for their students to solve, and students were asked to create their own stories to problems. Students were encouraged to discuss their solutions and to disagree with each other in a respectful manner. Students willingly presented their findings to the entire class. Students were given choice whether to work with a partner, a group, or individually. Although there were variations in frequency of how much one facet or another was observed, four observations (per teacher) offered an inadequate sample to securely claim that one teacher did something more than another. The sampling, however, was lengthy and detailed enough to assure that inquiry-based mathematics learning was transpiring in all of the classrooms.

I was left then with the dilemma: Why were the Roosevelt students scoring much higher on the state achievement tests, for both American Indian and other students? It was evident that all observed teachers had embraced and implemented inquiry-based mathematics and worked to involve students through their questioning strategies and subsequent student responses. Students new to the district did have initial difficulty adjusting to inquiry-based math. A higher turnover rate of students in Washington, Lincoln, and Jefferson, and perhaps related reduced level of opportunity to work with inquiry-based methods may have explained some differences in achievement scores. Still, both American Indian and non-American Indian students appeared to be engaged in their learning with the *Investigations* curriculum in all four classrooms.

The interviews that I conducted helped shed light on another possible factor that could account for the achievement difference between the schools and why the achievement gap between American Indian and non-American Indian students was smaller at Roosevelt elementary: homework and math game implementation.

Math games were encouraged at all four schools, yet in the first three the expectations did not contain the individual accountability that was evident at Roosevelt. At Lincoln Elementary where Hannah taught, homework was not assigned at the school; all math work was completed during class. Concerning the math games, grade-level classes did compete against each other to see which class completed the most math games during a week, but the number of games played by individual students was combined to get the total number of games played by the class. With this system, a high-achieving student could play many games that could mask other students not playing many. The results were posted as a bar graph in a hallway display for students to see. The graph was to serve as a motivator for students to play more math games to win the grade-level competition. At the beginning of the year, more math games were recorded; as the weeks went by, the total number of games played slightly decreased.

When asked about homework and the math games at Washington, Julian commented:

> In our *Investigations* book they have actual homework pages that you can send home. We have about five or six students that actually want homework,

> but they are the ones who don't need it. And so when I send it out, I'm lucky to get half of them back. I've learned in the past couple of years that it is like pulling teeth, it is more of a hassle. I'll send it out, but not everyone gets it back.
>
> We've tried sending home math games in the past couple of years and it is just like the homework. It's like the five or six kids that really don't need it; they are the ones that keep doing it every night. But it is the other ones, you know they come back and say they lost something or they don't have it with them, or they just didn't take it with them, so it is really a mixed bag.

Math homework was sometimes assigned at Washington, but not regularly and not with a high participation rate.

Emma answered the same question about homework and the math games at Jefferson:

> I only give them homework on Monday, Tuesday, and Thursday nights because Wednesday is usually church night. And weekends I believe are with your family, whether they get that family time or not. I don't want them to have homework when their mom and dad are there. Some of them don't ever see mom or dad, so I want them to spend all that time just being with mom and dad. So I give them that. But a couple of the assignments that ask for parent involvement have had very little parental involvement. Some of my students have a lot, but for the most part it is very little.
>
> I've always done math game folders in the past [at a different school] with some different games and I was pretty much told that it probably was not going to work as far as the students in Jefferson, because it doesn't get returned to school or it never gets done at home. I probably will try them, but I wanted to wait until I got to know the students' situations a little better. I will give them a try, but I have a feeling it will be exactly what they [teachers at Jefferson] said, that only some individuals will play the games.

Melissa, the Roosevelt fifth grade teacher I observed, explained that students were asked to play a minimum of ten math games per week as their homework. New games were regularly added to the binder as new math topics were introduced. Students were asked to work on games that challenged their math skills first and only after that to reinforce the skills by playing other games. Math game binders were due back to Melissa on Wednesdays. When students finished a game, they put their name, date, the name of the game, and how many times they played the game on a sheet inside the math game binder. A parent or guardian then needed to sign the sheet for the games to be counted for that week.

Thursday, after school, Melissa played math games with any student who did not successfully complete the ten-game minimum the previous week. Scheduling conflicts for these make-up sessions were very rare, but if students already had an appointment, they stayed after school on Friday. The math game binders were the students' homework every week, and very little (if any) other math homework was sent home. So students took the math game binders very seriously and saw it as a required time commitment. Like Melissa, the Roosevelt math teacher leader also played math games after school with any students who needed to play more games to meet the weekly requirement.

Students were aware that they would be completing at least ten games for homework each week. This helped eliminate forgetting math game binders and sign-off sheets from home. This was also the reason why the math game binders were due back on Wednesday; so those without their parents' signature could play the games after school on Thursday (or Friday). The math game commitment was taken seriously at Roosevelt and it was expected that parents would cooperate. The principal gave parents refrigerator magnets that said, "Roosevelt Parent Goal: To read 15 minutes nightly. Play up to 10 math games or more per week."

I asked Melissa if she had difficulties with parents signing the binders and she replied,

> As far as parents forgetting to sign off on the homework [math game binders], this doesn't happen often. If the kids forget them or the parent forgets to sign the binder for Wednesday, they know they can get them [the games] played or signed on Wednesday night. I treat the math games as a responsibility, just like we have in the real world. If you forget something, you usually have a certain amount of time or another chance to remember. And if you do not do your responsibility on your own, instead of a punishment, you just have to do it. They seem to get this, and aren't resentful about it. As fifth graders, I have the students call their parents on the phone, instead of me taking care of it. They make arrangements for after school plans, and it's about the students fulfilling their obligations.

I noticed that students played math games that accompanied the *Investigations* curriculum on 75 percent of my visits to Melissa's classroom. Perhaps it is the use of the games as both in-class activities and as Roosevelt homework that has helped students achieve more there.

But this observation has a more subtle, second layer to it: The different cultures of homework may have reflected race and class expectations related to how students at the different schools were imagined. These expectations could not be hard and fast of course — Roosevelt was a quarter American Indian in its enrollment; some students at all schools were from families economically successful enough not to qualify for free and reduced lunch, and so on — but there were variations in how the teachers described the enrollments in their classrooms. Emma, as an aside, speculated about whether her students actually had time with their families on weekends. Julian explained that only the handful of already successful students did homework, while at more successful Roosevelt, Melissa made affirming reference to her schools' expectations of doing homework as "just like the real world."

Conclusion

Ultimately, these four sites did not lend themselves to a direct test of whether or how inquiry-based mathematics education was helping American Indian elementary students or reducing achievement gaps. Through Project IBM, the Great Plains City School District had embraced an inquiry-based mathematics curriculum that used the CGI philosophy. That curriculum did seem aligned with what Hankes (1998) has called Native American pedagogy. Since 2003, concurrent with the district's adoption of *Investigations*, average math scores have improved. During observations of *Investigations* implementation, teachers acted as facilitators, and classroom interaction was mainly student-driven rather than teacher-directed. During classroom observations, American Indian students seemed as much involved with discussions and presentations as their White classmates. Yet between schools and between types of students within schools, gaps persisted.

The role of homework and the math games differed significantly at the four elementary schools. At Roosevelt, the math games were the weekly homework (and *there was* weekly homework). At Lincoln, no homework was assigned and the math games were used competitively between grade-level classes in ways that could hide low individual participation. At Washington and Jefferson, homework was assigned with mixed results, but math games were not used. The fifth-grade teachers at both Washington and Jefferson had low expectations on whether math games would be played or returned and attributed this to a lack of parental involvement.

Since 2003 and the implementation of *Investigations*, all students' mathematics test scores have improved notably, but the achievement gap has narrowed only slightly. Averaged across all grades tested (grades 3 through 8 and 11), the achievement gap in the district was 2 percent higher than the average for the rest of the state in 2003, as measured in terms of Cohen's Effect Size. Still, by the spring of 2009, the achievement gap in the district had declined by 11 percent whereas the achievement gap across the rest of the state had increased by 4 percent (Project IBM "Highlight" sent to NSF).

With Roosevelt Elementary, teachers had high expectations that their students would complete the weekly math games and an after-school "safety net" was provided for those students who were unable to complete the games at home by allowing them to play the games with the teacher or the math coach. Expected accountability of each student was different at that school; if students forgot the math games at home, it was their responsibility to call their parents to make arrangements to bring the games to school. The Roosevelt students rose to the challenge and raised their math achievement scores higher than the other schools examined (and the remaining 11 elementary schools in the district) and narrowed the achievement gap more than the other elementary schools in the district. Yet this dimension of Roosevelt's success was not followed at other schools perhaps because teacher expectations, related to the students they had, made it harder to imagine high expectations for all.

More can be done to raise American Indian student achievement in this school district, but adopting an inquiry-based mathematics curriculum seems to have been a move in the right direction. Following a Title VII program audit conducted by the U.S. Office of Indian Education, the school district's Office of Indian Education (OIE) was directed to focus on providing more academic

assistance to American Indian students. The newly hired OIE director requested the district's elementary and secondary math coordinators to provide workshops and materials to the Title VII staff working in Lincoln, Jefferson, and Washington Schools. This is perhaps a move that should have been initiated years ago, but we suspect it will only really matter if it affects teacher beliefs regarding students' capabilities. Although her comments were about junior highs and high schools, Jeannie Oakes's (1985) observation is highly pertinent:

> The first lapse [in our thinking about educational equality] is that in our search for the solution to the problems of educational inequality, our focus was almost exclusively on the characteristics of the children themselves. We looked for sources of educational failure in their homes, their neighborhoods, their language, their cultures, even in their genes. In all our searching we almost entirely overlooked the possibility that what happens *within* schools might contribute to unequal educational opportunities and outcomes. (p. xiv, emphasis in original)

To that we would add that even successful curricular change within schools does not appear to be enough if expectations related to different children still vary.

The district's OIE has a Parent Advisory Council (PAC) that meets monthly. Since the 2008 fieldwork, Title VII staff provided the PAC with an inservice on the *Investigations* curriculum that included a handout on effective questioning strategies to use with children while the child works on his/her homework. The parent resources, available online for parents to assist their children in their math learning (http://investigations.terc.edu/families/helping/), were shared. The math games were not mentioned in the training but the four elementary schools have continued to hold family math nights at least once per year. More could be done to promote the math games as a means of homework and family involvement.

Delpit (1995) asserted, "One of the most difficult tasks as human beings is communicating meaning across our individual differences, a task confounded immeasurably as we attempt to communicate meaning across individual differences, a task confounded immeasurably as we attempt to communicate across social lines, ethnic lines, cultural lines, or lines of unequal power" (p. 66). These are issues that the school district's elementary teachers (and teachers in general) must work with collaboratively to provide an equitable education for *all* students. Teaching in the United States is one of the most challenging and least valued professions, but teachers must be cognizant of how their human and social characteristics influence teaching (Grant & Gillette, 2006). By honestly examining their attitudes and beliefs about themselves and others, teachers begin to discover why they are who they are, and can confront biases that have influenced their value system (Villegas & Lucas, 2002). The philosophy of education for all teachers should concern what is best for students — American Indian, White or any ethnicity — we must follow educational paths that works for *all* children. As Julian teaches: *Mitakuye oyasin* (We are *all* related).

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