NATIVE RESERVE STUDENTS’ AND NATIVE PUBLIC SCHOOL STUDENTS’ WAYS OF KNOWING MATH

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Abstract / Résumé

The purpose was to reveal if problem-solving performances and mathematical understanding of Native students attending Reserve Schools differed from problem-solving performances and mathematical understanding of Native students attending Public Schools. Eighteen Grade 3 students and eight teachers in Reserve and Public Schools participated. Data analysis was a qualitative case study and static group comparison (Neuman, 1997). Results showed Reserve School students more confident in mathematics but weaker in numeration, and rated mathematics as less important than those students in Public Schools; however, Reserve School students were stronger in spatial relations and measurement. Six Blackfoot preservice teachers assisted in data gathering.

L’étude visait à vérifier si l’aptitude à résoudre les problèmes et la compréhension mathématique des élèves autochtones des écoles de bande étaient différentes de celles des élèves autochtones des écoles publiques. Elle a engagé la participation de 18 élèves de la 3e année et de 8 enseignants provenant d’écoles de bande et publiques. L’analyse des données a pris la forme d’une étude de cas qualitative et a eu recours à un groupe de comparaison statique (Neuman, 1997). Les résultats ont indiqué que les élèves des écoles de bande étaient plus assurés en mathématiques, mais plus faibles en numération, et qu’ils accordaient moins d’importance aux mathématiques que les élèves des écoles publiques. Toutefois, les élèves des écoles de bande étaient plus forts en organisation spatiale et en mesure. Six enseignants pieds-noirs en formation d’orientation ont participé à la collecte des données.

Introduction and Purpose of the Study

The purpose of this study was to investigate the conundrum of Native poor performance in Western mathematics versus Native successful mathematics performance in real-world mathematics. Results of Native students' performance in Western math tests indicate that Native student performance is poor but at the same time research informs us that Native people are very capable problem solvers. Puzzling as that is, it does lead us to such questions as why is this so and how is it possible? The impetus that drove our research was to understand how Native students learn mathematics and solve problems best. McEwan (2006) echoes this study's impetus that there is a need for cultural sensitivity training and supports for metropolitan school authorities to assist Aboriginal learners. Further support for Native student success emanates from the *Alberta Commission on Learning Recommendations*. It states: “…the Commission believes that concerted and deliberate actions are needed…. ‘Success for every child: Adapting programs and providing support so that all children, including Aboriginal children…get every opportunity to succeed in school’” (5).

The Research Study

Broadly, our study compared the similarities and differences between Native students’ math problem solving in their Native culture (Reserve schools) and Native students’ math problem solving in a non-Native culture (Public schools) in the Blackfoot Confederacy, Alberta and Montana. To carry out the study we invited Grade 3 students and their teachers in the Blackfoot Confederacy to participate in surveys. The instruments were eight paper-pencil test questions for students, and demographic and attitude surveys for students and teachers.

We chose Natives’ cultural/ethnic factors and Natives’ unique mathematical understandings to further investigate ways in which Natives learn mathematics. Our principal research question was: “Is the problem-solving performance and mathematical understanding of English-speaking Native students attending Reserve Schools, where the students’ cultural environment is Native, different from the problem-solving performance and mathematical understanding of Native students attending Public Schools, where the students’ cultural environment is non-Native?”

Background and Literature Review

Although Native people have ably solved problems for at least 60,000 years (Perso, 2003), research to date is inconclusive as to why
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they do not perform so well in Western mathematics, and that, in part, reflects their lack of success in high school completion. Almost half of Aboriginal Albertans have not completed high school, compared to about 30% of immigrants and all non-Native Albertans (McEwan, 2006). Similarly, the Montana Native high school non-completion rate is more than three times the rate of non-Native (Aronstamm Young, 2003). Riha Linik, (2004) speaking for Montana Northwest Education Journal, suggests that there are obvious ways to deal with the Native student low completion rates:

...Native students...suffer from the lowest high school completion rates in the nation. The research suggests—and common sense tells us—these students might benefit significantly from having role models to guide them, as well as access to more culturally sensitive and culturally relevant instruction. (¶ 4)

Cajete (in Antone, 2000) underscores the importance of cultural ways of knowing. He states: “...[education] foundations teach us that learning is a subjective experience tied to a place environmentally, socially, and spiritually” (97). A careful examination of these contributing factors, with a special emphasis on ways of knowing, can make math education more meaningful and effective in raising achievement test results and Native students’ efficacy. For many Native students this means that mathematics should be taught in a respectful manner using culturally illustrative examples and storytelling.

Instruction that integrates the cultural knowledge or cognitive background and language of the Native student promotes deep learning (Apthorp, D’Amato, DeBassige, & Richardson, 2002; Barta, 1999; Barta, 2005; Barta & Schaeiling, 1998; Cohen & Hill, 2001; Corbiere, 2000; Davidson, 2002; Ezeife, 2002; Funkhouser, Porter, & Ipina, 2000; Hegeman, Henry, & Scott, 1988; Kehoe & Echnols, 1994; McDonald, 1989; Nelson-Barber & Estrin, 1995; Pinxten, 1991; Semken & Morgan, 2000; Shirley, 1995). Education that integrates students' ways of knowing also has benefits for instructors. Listening to the life histories of Native speakers helps educators become more aware of culturally appropriate education. Leavitt (in Antone, 2000) states, “Life history, whether spoken or written, is helpful because it contains not only reflections on education but also indications of the cultural context in which learning and teaching take place” (183). With the advent of culturally appropriate ways of learning and teaching “the Native voice will be illuminated” (Antone, 97). Such research to date suggests that for Native students, education that is characterized by shared resources, that is not time orientated, but rather with the provision of many opportunities for observation, deep
learning and efficacy results.

**Theoretical Framework**

To measure the impact of “ways of knowing” (Belenky, Clinchy, Goldberger, & Tarkle, 1986; Kawagley, 1990; Walker, 1999; Zuga, 1999), we combined elements of a qualitative case study and a static group comparison (Neuman, 1997). Essentially, we aimed to investigate the mathematical performance of Native students within their **real-life context** in two school settings, Reserve Schools and Public Schools, to explore the constructive and sociocultural perspective of Native students’ problem solving.

**Data Gathering Instruments**

Students used textbook-type paper-pencil math problems taken from the Alberta Grade 3 Mathematics Achievement Test (Alberta Education, 1997). The Montana and Alberta math programs of study were similar, as were the state and provincial tests (Great Falls Public Schools, 2007). We chose test questions representative of the math strands from The Alberta Grade 3 Mathematics Achievement Test, 2000.

**Participants**

We limited the investigation to two groups of Grade 3 Native students educated in their cultural context (Reserve Schools) and those in a non-Native cultural context (Public Schools). We chose Grade 3 (8-9 years old) for four reasons: (a) 8-year old Native Reserve School students would be less likely influenced by non-Native culture than older children; (b) Public School and Reserve School students would be mature enough to be interviewed and demonstrate their understanding of Western mathematics; (c) all would be less influenced by Westernized mathematics textbooks and teaching methods than older students because of only three years of formal schooling; and (d) Grade 3 students were tested formally in both Montana and Alberta on similar programs of studies (Alberta Education, 1997; Montana Standards, 1998).

**Procedure**

We used a modified clustering sample method to recruit Grade 3 Native students in the Blackfoot Confederacy, and their respective teachers, Native or non-Native. In this exploratory study we aimed to meet the sample size of forty students. Our actual numbers were fewer than the ones we proposed: we had three teachers and six students from a Reserve School sample and five teachers and twelve students from a
Public School sample. Since this was the second pilot study, a small sample size, although a limitation, was not a major concern.

**Surveys**

The students completed a two-part survey: (1) a likert scale to collect demographic data and math attitude questions (Anderson, 1988a, 1988b); and (2) eight paper-pencil mathematics problems from the released Grade 3 Mathematics Achievement Test, 2000 that was based on the Alberta Program of Studies (1997), a similar program to the Montana Standards for Mathematics (1998). Both programs contain number, patterns and relations, and shape and space/measurement strands. After the students did the pencil/paper problem-solving questions the Native preservice teacher research assistants offered a token gift for their efforts.

*Teacher survey.* Given that research has shown teachers’ attitudes towards the mathematics they teach has a profound impact on their students’ attitudes towards mathematics and achievement in mathematics (Aitken, 2000a, 2000b, 2003; Andrews, 2000; Bourke, 1986; Ma, 1999; Relich, 1996; Tobias, 1993; Wilensky, 1997), to control for the potentially confounding variables of teachers’ attitudes towards mathematics, education major, years teaching, and education history/background, the research assistants asked teachers to complete a demographic and attitude questionnaire (Anderson 1988a, 1988b; Thorndike, 1988; Wolf, 1988; Zeller, 1988).

Following the attitude questionnaire the research assistants gave similar semi-structured interviews to teachers, and used probes for clarification. These questions were a check for the reliability and validity of the questionnaire and provided additional information about teachers’ perceptions about improving preservice mathematics education (Thorndike, 1988; Zeller, 1988).

**Data Analysis**

We suggest there are some differences between teachers and students in the two settings. Qualitative and quantitative analysis methodologies were used to compare differences as a function of school setting. QSR N.U.D.I.S.T. software was used to analyze students’ and teachers’ responses to interview/survey questions. Thematic analysis of student responses revealed that reserve teachers reported spending more time on numeration, whereas public students more often reported being “good” in mathematics. SPSS Version 17 was used to generate descriptive statistics, chi-square statistics, and t-tests for teachers’ and students’ attitude (Fennema & Sherman, 1976) and achievement scores.
Additionally, we carried out Item Response Analysis on students’ responses to gain insight into the similarities and differences between the two groups with respect to selection of distracters and overall response patterns.

**Results**

All teachers like teaching students mathematics, dislike the lack of mathematics resources available for teaching, and spend the majority of time teaching number operations.

*Teacher Characteristics.* Reserve teachers did not differ significantly from Public School teachers with respect to years teaching math, or highest level of math course taken (p < .05).

*Teacher Attitude Results.* Reserve and Public teachers had similar attitudes towards mathematics. The only question where groups differed significantly was a question that asked teachers to rate the importance of mathematics in their daily lives. Public teachers rated mathematics more important than Reserve teachers.

*Student Attitude Results.* Reserve students’ math attitudes were quite similar to those of Public school students’ except when asked, “If you have a different answer than another student, the other student is usually wrong.” Reserve students were more likely to answer “not sure” or “agree” than were Public School students, indicating that Reserve students were more confident with their answers than Public students.

*Student Achievement.* The proportion of correct and incorrect responses for each paper/pencil question was statistically similar for Reserve and Public students. The overall mean achievement scores were similar for Reserve students: (M = 5.5; SD = 1.2), and Public students (M = 6.2; SD = 2.4; SE = .683) (p = < .05).

**Other Interesting Results**

*Teachers.* One interesting dissimilarity was observed: Reserve teachers reported spending the most time (after number operations) teaching place value while Public School teachers reported spending more time on measurement.

*Students.* All students indicated math is important; however, only Public School students related the importance of math to getting a good job.

**Significant Findings**

1. *Native Public School students’ weak self-concept.* Reserve students were more confident that their answers were correct. This correlates with the research that shows Native students in Public settings are
less confident than Native students in Reserve settings in their mathematics abilities (Aikenhead & Huntley, 1999; Davidson, 2002; Demmert, 2001; Hegeman, Henry, Scott, & McDonald, 1988; Preston, 1991; Schilk, Arewa, Thomson, & White, 1995; Trumbell, Nelson-Barber, & Mitchell, 2002; Wilson, 1997).

2. **Native students’ weak numeration.** Place value is difficult for Native students to grasp. Assuming this is difficult for students because of the time spent teaching it, this is consistent with Hankes (1996) and Witthuhn (1984), who found that Native students have difficulties with all aspects of Westernized mathematical processing, and in particular, numeration.

3. **Native Reserve Students’ strong spatial relations and measurement (linear).** Reserve teachers spent less time teaching spatial relationships and measurement than Public School teachers, and yet, these concepts were strengths for Native Reserve students.

**Recommendations**

What can educators learn from this study that will assist them with effective ways of Native teaching and learning? In brief, teachers can focus on weaknesses through encouragement so students overcome them to improve their self-concept and numeration. In addition, teachers can focus on strengths to further enhance Native students’ spatial relationships and measurement, and confidence.

1. **Native Public School students’ weak self-concept.** This is evident in terms of stating they are good at mathematics but not in terms of confidence in their answers. Although the overall Reserve students’ attitudes to mathematics are similar to those of Public students, the one exception was the question that asked students “if you have a different answer than another student, the other student is usually wrong.” Reserve students were more likely to answer “not sure” or “agree” with this statement than were Public students, indicating that they were confident that their answer was correct. This correlates with the research that shows Native students in Public settings are less confident than Native students in Reserve settings in their mathematics abilities (Aikenhead & Huntley, 1999; Davidson, 2002; Demmert, 2001; Hegeman, et al., 1988; Preston, 1991; Schilk, et al., 1995; Trumbell, et al., 2002; Wilson, 1997).

Public school teachers should take every opportunity to encourage Native students and find ways to boost their confidence, not only in math, but in other subjects as well. Once confidence is strengthened, the student feels empowered to take risks, ask pertinent questions, and understand that problem solving takes time and that there are many
ways to solve problems.

2. Native Reserve School students’ weak numeration. Reserve teachers spend the most time (after number operations) teaching place value. Assuming this is difficult for students because of the time spent teaching it, this is consistent with Hankes (1996) and Witthuhn (1984) who found that Native students have difficulties with all aspects of Westernized mathematical processing; in particular, numeration.

To help students understand place value, Reserve teachers could have the students use manipulatives such as base 10 blocks, Cuisenaire rods, money, etc., so that students have a visual and concrete aid of the value of ones, tens, hundreds, thousands, etc., and be able to construct these values using manipulatives to further solidify the concept, and “bring math alive” in real-world contexts.

3. Native Reserve School students’ strong spatial relations and measurement. Research indicates that this is a global phenomenon since Australian Native students have strong measurement and spatial abilities (Perso, 2003). Native children from an early age need to be fully aware of their location and direction in their particular environment for survival (J. Barta, personal communication, February, 2004; Perso, 2001).

Reserve teachers can capitalize on this strength to further strengthen confidence, and integrate the measurement context with numeration, such as place value. Once students have success in one mathematical area, they are more likely to try strategies and take risks in another area, particularly if they see the mathematical connections and the relevance of the math problem in everyday life (Ma, 1999; Shulman, 1986).

Discussion and Recommendation for Further Study

We have continued this study in 2007-2008 because we had not been able to collect sufficient data from Reserve Schools to compare with the Public Schools and make any definite statements; however, research and informal observations indicate that Reserve school teachers lack a strong understanding of mathematics. Very few Blood Reserve Grade 12 students have been entering the sciences in post-secondary studies because they lack the necessary background to enter these disciplines. Mathematics is a core requirement to enter university science classes and most Reserve students do not graduate from high school with these courses.

One reason for the Native students’ weak mathematical understanding and confidence overall compared to non-Native students (Davidson, 2002; Demmert, 2001; Kehoe, & Echols, 1994; Trumbell, et al., 2002) may be the lack of math background of their Reserve school teachers. The depth of math knowledge that teachers bring to the education program
has a bearing on how well they will teach and how well their students will learn (Aitken, 2006; Ball, 1990; Even, 1993; Simon, 1993). Research reveals that math education in much of the Western world is mired in a cyclical problem, that weak math teachers beget weak math teachers (Aitken, 2003).

Many of our teachers in the Blackfoot Confederacy choose Native Education, Social Studies, and English, and avoid Mathematics and the Sciences in their undergraduate programs (J. Lavorato, personal communication, 15 November 2007). This results in that too few have the necessary skills required to teach and maintain interest in our students' natural instinct in mathematics and the sciences. While avoiding math and the sciences is also the case for non-Native preservice teachers, it appears from informal observations in this 2005-2007 study that it is more likely the case with Native preservice teachers; however, this observation must be met with caution because of our small sample size.

Our Native students may have the confidence in math in the primary grades, but by the time they reach the secondary grades they have streamlined into the less challenging and demanding courses, and into applied mathematics instead of the more abstract pure mathematics that is required for advancement in university programs. Therefore, this may indicate their lack of success in mathematics somewhere in the middle-school years or the lack of hands-on opportunities in real-world contexts early in their schooling to strengthen skills required for conceptual understanding in future mathematics lessons involving abstract concepts.

The concrete sequential learning required in primary grades is essential for secondary learning to take place (National Council of Teachers of Mathematics, 1995). Secondary mathematics is mostly taught in an abstract form and relies on students' knowledge, skills, and conceptual understanding from primary grades. These instructions cannot solely be based on worksheets and counting but on the real-world problem solving and skills tested in our study. Our observations show that contrary to teaching the ways in which it might be more natural to Native students, such as observation, and hands-on activities in relevant contexts, Native teachers tend to favor worksheets and abstract procedures. This observation is supported by research that shows this is particular to all teachers with weak conceptual and content knowledge:

Lacking appropriate content knowledge, their teaching is algorithm-bound—children are taught by rote and learn by rote—or, are activity bound; teachers do not know how to be explicit about the mathematics that can be drawn out of an activity. (Le Maistre, Brown, & McDuff, 1994: 4-5)
For these teachers and their students, mathematics is little more than following rules, and memorizing procedures. Teachers who lack “profound understanding of fundamental math” lack “pedagogical content knowledge,” that is, having the skill and understanding to represent and formulate the subject that makes it comprehensible to others (Ma, 1999; Sánchez & Llinares, 2003; Shulman, 1986). Alternatively, teachers who have had university-level math courses possess stronger math understanding and skills, and more positive attitudes than those who have not. These teachers pass on their strong skills and positive attitudes to their students (Afrassa & Keeves, 1999; Dungan & Thurlow, 1989; Keeves, 1972, 1975; Ma, 1999; Milne, 1992).

This study's purpose is to raise awareness about the importance of teachers’ pedagogical content knowledge to give our Native Reserve (and off-Reserve Native teachers) the information and professional development required for effective and successful mathematics instruction. Our study is not an achievement test to make ranking comparisons, nor is meant to place students in special-needs classes, or to rank and sort individual schools; but rather, it is for research to further enhance future mathematics teacher development to provide insights, to suggest possible directions, to promote collaboration and trust among stakeholders, and to facilitate productive dialogue about Native mathematics education. We need to take these proactive steps in Native mathematical and science education—and that includes all levels of government and associated parties: school districts, Bands, teacher education, teachers, and parents. After all, at the end of the day, it is really is “up to us” (Ihipipo’tootspa).

Endnote

Blackfoot Preservice Teachers' Participation

Equally important in this study was the Blackfoot preservice teachers’ participation. The study provided a significantly rich opportunity for them to be meaningfully involved in their own culture’s way of learning mathematics, and an opportunity for using their Blackfoot language. The school administration, teachers, and Grade 3 students responded very positively to the Blackfoot preservice teachers’ involvement, and commended the study for this aspect. These now newly graduated teachers are determined that they will continue on to Master's degrees and carry out research in Native education to help narrow the Native and non-Native mathematics achievement and efficacy gap.

As a result of the study, we strongly recommend that Native people be involved in Native research where they can make a positive contribu-
tion to their society, improve their self-esteem, and use their mathematical prowess. Ezeife (2002) underscores Native people's mathematical potential: “If the teaching approach is changed, the curriculum made culture-sensitive and environmentally oriented, we may look forward to producing Aboriginal world-beaters in the discipline of mathematics” (186).

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