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ABSTRACT

Two studies appear to reach unsatisfactory conclusions regarding causes of low math achievement among American Indians. Leap (1988) studied math problem-solving strategies among low-math-achieving fourth- and fifth-grade Ute reservation students. He concluded that faulty or cumbersome problem-solving strategies were directly linked to Ute language and culture. However, Leap failed to compare his results to a national math assessment study that would have shown that Ute students are actually fairly strong in problem-solving skills. A second study by Witthuhn in 1984 investigated the relationship between socioeconomic status (SES) and math achievement. Although SES and ethnicity are significant predictors of math success, low-income Indian and Black students demonstrated an unpredicted strength in geometry. The study failed to investigate what it was about low SES communities of Blacks and American Indians that allowed them to develop superior geometric ability in spite of educational disadvantages due to poverty. The author's own experience as a child of an Indian father and Swedish mother living in poverty involved low math achievement, low self-esteem regarding math ability, and limited math exposure in the home. Negative school experiences exacerbated her low math achievement. There is a need for researchers to collaborate and develop a united front to pursue resolution of the "Indian mathematics problem." (KS)

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A Call for Collaborative Research to Investigate the "Indian Math" Problem

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Abstract

Within this paper a brief literature review documents the existence of low math achievement among American Indians. Two studies investigating the problem are analyzed, and a personal narrative is shared. The intention behind integrating these texts is to illuminate the need for researchers to collaborate, to integrate efforts and share in discourse, to develop a united front to pursue resolution of the "Indian mathematics problem."

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A CALL FOR COLLABORATIVE RESEARCH TO INVESTIGATE THE "INDIAN MATH PROBLEM"

Poor performance and limited participation in mathematics by American Indians has been well documented throughout the nation (Christensen, 1982; Clever, 1982; Cajete, 1988; Preston, 1991; Hadfield, 1992). In a paper prepared for a math equity conference, Johnson (1982) reported that while 30.3% of all white students nationally take six or more semesters of math in grades ten through twelve, only 10.9% of all American Indians did so (17.3% of all Hispanic students and 19.4% of all black students). A comprehensive study completed in 1983 indicated that American Indians were 1.7 years behind the national norm in grade six mathematics achievement and three years behind the norm at grade twelve and the proportion of special needs in mathematics increased from 32% in grade two to 41% in grade four and 46% in grade six (Fletcher, 1983). Another study with Ute students in northeastern Utah (Leap, 1988) helps illuminate how limited mathematics proficiency among primary and secondary Indian students impacts on Indian people in general. Leap concluded that poor mathematics performance extends beyond ineffective problem solving to affective domains as well. He found that Indian children who remained in school (school-leaving becomes a real issue by grades 8 or 9 among Indian children across the nation (Fries, 1987)) tended to avoid enrolling in mathematics courses or in other courses where mathematics held a significant role in course content. Career choices were often made along similar lines with Ute students rejecting careers that emphasized the need for quantitative skills and favoring career options where qualitative skills were stressed. Consequently, virtually no members of the Northern Ute Tribe have been educated in "hard" sciences, in engineering, in energy-related science, or in business management. It is important to note that this situation is common among tribes across the nation and has serious implications for economic self-determination as well as for political self-sufficiency for all American Indians (Lane, 1988).

As indicated above, a considerable amount of research has documented the "Indian mathematics problem" and its consequences; however, relatively limited study has focused on the causes of the problem (Cheek, 1983; Fletcher, 1983; Scott, 1983; Witthuhn, 1984). Furthermore, the attempts by researchers to gain insight into this matter resemble the efforts of the proverbial blindmen describing an elephant: one feeling its side thinks it's a wall and another feeling a leg thinks it's a tree, etc. - one line of research attributes the problem to the low expectations for Indian students held by teachers, counselors, principals (Nash, 1973; Green et al., 1978), and parents (Ortiz-Franco, 1981); another dwells on the impact of equity and opportunity and the influence of low socio-economic status on performance; still another attempts to link math avoidance to linguistic factors and familiarity with traditional tribal strategies and culture (Leap, 1988); and more recently, cognitive aspects have been explored (Hadfield, 1992). However, for researchers investigating this critical issue to avoid the blindmen's fate of reality distortion, it is vitally important that members of the research community participate in shared analysis and interpretation of their findings. Opportunities for mathematicians, linguists, anthropologists, sociologists, and cognitive psychologists must be coordinated to promote integrated discourse. Only through this type of carefully concerted effort can strategic plans be made to bring about change.

Negative Indigenous Culture Influences

A careful analysis of one study, a study which has received a fair amount of recognition and aspired to the status of chapter inclusion in a bound text, exemplifies the blindmens' distorted reality described above. Leap (study completed in 1982 and published in 1988), a linguist and anthropologist, investigated the ability of Ute reservation students to solve mathematical word problems. He situated his study as an effort to explore cultural influences on oral and written mathematics problem solving. The research methodology for this project involved one fieldworker conducting a set of interviews with 18 randomly selected low math achieving fourth and fifth grade students and analysis of the interview transcripts. Leap concluded from this analysis that the 18 students used four cumbersome and potentially ineffective problem solving strategies that were directly linked to the Ute language and culture. Assumptions about word problem solving were also identified. Below, the strategies and assumptions are listed, as well as two examples of students' transcribed solutions and Leap's comments about the solutions:

Problem-solving Strategies of Ute Students

1. Convert the problem into simple addition and subtraction.

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2. Use clues from the text and other sources to develop a generalized, open ended solution to the problem.

3. Disregard details in the text and work directly with the number values presented by the problem.

4. Assess the truth value of the conditions outlined in the problem, then develop your answer accordingly.

5. Solve the problem in the manner originally intended.

Problem-solving Assumptions of Ute Students

1. Word problems are problems, and problems are to be solved.

2. Solutions to word problems can be found by drawing on personal knowledge and expertise; solutions should not be found by relying on the knowledge and expertise of others.

3. Whatever else their intent, solutions to word problems should always be consistent with the perceived intent of those problems.

Student Strategy Example #1

F: Okay, let's try this one. (reads) "If a boy was paid four dollars a day for working in a store . . ."
U3: (reads) ". . . how many days will he have to work in every thirty-six dollars." Mmm.
F: ". . . to earn thirty-six dollars."
U3: Okay, he gets four dollars and times thirty-six, and he has to, um, okay that's eight, sixteen, twenty, twenty-four, twenty-eight, thirty-two, thirty-six, okay, that would be the end. That's um, one, two, three, four, five, six, seven, eight, nine - nine days.

Leap's Comments

Conversion from multiplication to addition appears to have been a useful problem-solving techniques under these circumstances. Use of this strategy does make high per-problem demands on the student's time, something that could be serious during the end-of-quarter examination or on a standardized achievement test. In some cases during the interviews, use of the strategy seemed to have increased the possibility that the student would make an error during the calculation.

Example #2
Leap's Introductory Comments

(In one case) the fieldworker pointed out the error and showed how the addition sequence needed to be altered, the student was quickly able to complete the sequence and come up with the corrected answer. In other examples, the student appears to concentrate so forcefully on completing the "converted" calculation that the fieldworker's attempts to provide corrections is almost completely ignored:

F: Can you figure out how to do that one (pointing to problem)?
U6: Seventy-two pennies, seventy-two divided by, um (starts to count in a low voice) -
F: . . . you started to say "seventy-two divided by . . ." What was that going to be?
U6: (still counting in a low voice)
F: Seventy-two divided by?
U6: Four.
F: Uh-huh.
U6: (begins to mark on the scratch paper) Four into four is . . .
F: (corrects the set-up of the division problem)
U6: Four divided by seventy-two equals . . . four, eight, twelve -
F: (interrupts) Do you know how to do long division?
U6: - sixteen -
F: Okay.
U6: Twenty. (pause) Twenty cents each.
F: Okay. That is pretty close.
U6: Twenty-four.
F: No. How did you get that twenty?
U6: I don't know. (erases part of her calculation and begins the process a second time)

Leap's Comments

Certainly, converting the arithmetic tasks outlined in a problem from multiplication or division into simple addition (or subtraction) reflects the student's awareness of the similarities underlying these operations. Even so, as these examples suggest, awareness of those similarities does not prevent other factors from interfering with the accuracy of the answers that this strategy creates.

A casual reader or one not familiar with the extensive literature on children's math solution strategies (Carpenter, 1985; Carpenter & Moser, 1983; Carpenter & Moser, 1984; Riley, Greeno, and Heller, 1983) might feel inclined to credit Leap with identifying credible evidence that links Ute culture and language to low math achievement, especially when he supports his many interpretations with statements like:

> Ute students' use of addition when the word problem calls for multiplication suggests the fusing of these two concepts under a single lexical item that always happens during ancestral language discussion of western mathematics. . . . recognizing that most Ute students come from homes and communities where other aspects of tribal traditions are still very much a part of daily life, it is no wonder that details from Ute language tradition help structure Ute student approaches to mathematical problem solving . . . .

However, Leap's attempt to implicate cultural influences is questionable, and his inclination to generalize the target populations' (low math achievers) use of what he identified as inferior strategies adn assumptions to all Indian students, implies limited scholarly reflection. He pessimistically concluded his study with the following sentence:

> Perhaps it is now clear why the "Indian mathematics problem" continues to be a source of major concern for all Indian educators, and why, even when the problem is recognized, truly effective remediation strategies have yet to emerge.

It is important to point out that Leap's choice to generalize study findings to all American Indian students was not inapproopriate, it was simply incomplete. Had he discussed his findings with the community of mathematics education researchers, he would have learned that some of his observations parallelled those of the Fourth Mathematics Assessment (Carpenter, et al., 1981), a national math assessment study, and that others illuminated problem solving strengths rather than weaknesses. Similarities and dissimilarities between studies become apparent with the reading of the following quotations taken from the assessment summary:

* One of the consequences of students learning mathematical skills by rote is that they cannot apply the skills they have learned to solve problems. In general, NAEP results showed that the majority of students at all age levels had difficulty with any nonroutine problem that required some analysis or thinking. It appears that students have not learned basic problem-solving skills.

* Although students could successfully identify which operation should be used to solve most simple one-step problems, they had a great deal of difficulty analyzing nonroutine or multistep problems. In fact, given a problem that required several steps or contained extraneous information, students frequently attempted to apply a single operation to the numbers given in the problem.

* Even when students could apply the appropriate operation to use to solve a problem, they frequently had difficulty relating the results of their calculation to the given problem in nonroutine situations.

By limiting his discourse to the communities of linguists and anthropologists and not comparing the Ute students' strategies to the national mathematics study, Leap missed an opportunity to credit low math achieving Ute students with possessing fairly strong problem solving skills, and by limiting his generalizations to Native Americans, he further contributed to the perpetuation of the defeatingly negative assumption that American Indians are by nature mathematically inferior. Perhaps his conclusions belie his own assumptions regarding the math incompetence of American Indians, and, consequently, low expectations were what informed his choice to recommend "effective remediation" rather than appropriate instruction. Furthermore, Leap's emphasis on standardized achievement and computation suggests that his form of remediation would focus on timed computation drills to develop rote skills, the very skills that the NAEP study identified as requiring little analysis and thinking. As cautioned earlier in this paper, it is possible that Leap's study has contributed to the "Indian math problem" by authoritatively claiming that indigenous culture negatively impacts on math learning, that the "side of the elephant is a wall".

SES and American Indian Math Performance

A second study of critical importance to those concerned with the "Indian math problem" was reported by Witthuhn in 1984. This study was an investigation of the patterns of mathematics performance among elementary aged students in the Minneapolis Public Schools during the 1982-83 school year. In 1982, the district implemented a five-year reorganization plan to improve the educational experience delivered to its 40,197 students. Improving the achievement level of the 13,992 minority students (22.4% black, 6.0% Asian, 5.0% American Indian, 1.4% Hispanic) was a major goal of the five-year plan. In order to better monitor student progress and identify students in need of special intervention, the district implemented a testing program in reading, writing, and mathematics and correlated the scores with student ethnicity, gender, and socioeconomic status. Eligibility for free or reduced lunches was used as a measure of socioeconomic class.

An analysis of variance indicated that ethnicity and SES were significant predictors of math success. Specifically, data analysis revealed that being black or being Indian was related to being from the lower socioeconomic class and to scoring poorly on the mathematics tests. Among the older students included in this study, being black was also related to being highly mobile. Being white was related to being in the higher socioeconomic class, being nonmobile, and scoring well on the mathematics tests. Differences by gender were not statistically significant.

Data analysis was also completed to determine whether differences between ethnicity and SES existed consistently throughout all portions of the mathematics curriculum or if subgroups of students had unique patterns of strengths and weaknesses. Results revealed that Indian and black students demonstrated strength on the geometry strand of the mathematics curriculum. Witthuhn observed that this area of strength, relative to their poor performance on the other strands, was of even more importance when contrasted with the performance of the other ethnic groups, all of whom demonstrated weakness in geometry. Based on these findings, recommendations were made to develop teaching strategies that built on this strength for Indians and blacks, such as, greater use of manipulatives and other hands-on experiences for geometry instruction as well as instruction of classification, ordering, the construction of the idea of number, and all of the other operations which Piaget (1960) identified as part of the concrete operations stage.

Within the report summary, Witthuhn, disregarding the preceding finding, made the following observation and suggestion:

> Indian and black students have special difficulty with numeration. Mathematics instruction tends to be strongly linear in nature, with numeration being basic to all other components of that instruction. It may be that majority children bring to the study of mathematics a set of experiences which allow them to master numeration concepts as they are usually taught in the primary grades. In order for Indian and black children to achieve similar mastery, it

may be necessary to do a more thorough analysis of the desired terminal capabilities (Gagne, 1963) associated with numeration and of the prerequisite skills and behaviors which must be assessed and taught.

The Minneapolis School District's inclination to investigate the relationship between ethnicity, gender, and SES reflects an attitude of equity based scholarship. Those orchestrating this investigation sensed that something influenced performance but was uncertain of just what it was. And Witthuhn's recommendation, above, for analysis of the skills needed for successful mathematics performance, the performance demonstrated by the majority population, was logical. However, her choice, after recognizing the superior geometric ability of black and Indian children, to recommend that their instruction be based on Piaget's concrete operation stage, marginalized this ability as a mode of remediation when compared to that which "majority children bring to their study . . . which allows them to master numeration concepts as they are usually taught in the primary grades." A more thorough study would have included investigating what it was about low SES communities of blacks and American Indians that allowed them to develop superior geometric ability inspite of educational disadvantages due to poverty.

The Minneapolis School District study has contributed greatly to resolving the "Indian math problem". Not only did the study positively correlate a relationship between low socioeconomic status and poor math performance among Indian students, it also provided evidence to document a mathematical strength. These two findings, when pursued farther through the lens of educational psychology, will prove highly informative. Witthuhn's recommendation to study the majority population's math experiences to determine what allows them to master numeration concepts reflects the type of cognitive based research needed to investigate the geometry strengths of Indians and blacks, psychological investigation based on the belief that children actively construct knowledge for themselves through interactions with the environment (Steffe et al., 1983). Witthuhn's casual regard for the importance of this finding qualifies her to be situated with the elephant touching blindmen. She identified a significant difference, yet chose not to recommend research into what it was about poverty that caused the difference. Perhaps she is not to blame. Perhaps the quantitative constraints of research methodology common in the early 1980s discouraged her from pursuing such a complex affective issue. However, today's qualitative research methods might prove to be of extreme value when attempting to understand the influence of environmental differences on the formation of linear and spatial thinking. Perhaps it will be through the analysis of multiple life stories, narratives, and case studies that we will learn to understand poverty's influence on achievement and failure.

A Personal Narrative

During all of my elementary and secondary school years, I qualified for free school lunch. So, according to the study described above, I would have been categorized as low SES. Until two years ago, I also believed myself to be cognitively inferior mathematically, as my GRE math scores testify. I avoided mathematics courses in high school, choosing to take only the basic requirements: general and consumer math. Because of high science placement tests scores, I ended up being tracked into biology, chemistry, and physics. However, lacking the math skills needed for chemistry and physics, I barely maintained passing grades. It wasn't that I struggled in these courses, I simply reconciled myself to the fact that I couldn't do math and didn't try. I remember perplexed teachers assuring me that I would do fine if I just applied myself. I shrugged their encouragement off and clowned my way through the courses. According to Witthuhn's study criteria, I was definitely mathematically low achieving.

Why did I feel as I did about math? What was it about my childhood that led me to first devalue math, as I'm certain that I did, and later to think of myself as mathematically incompetent? As I inferred above, my family was very poor. Economically, we were at the bottom of the poverty scale. Mama and Papa homesteaded a small island fifteen years before my birth. On this island, they conceived, birthed, and reared five children, two girls and three boys. I was the youngest. In the summer, Papa worked odd jobs, and during the winter he trapped. Mama didn't work a paid job, but she worked - carrying drinking water, washing clothes by hand, gardening. Domestic violence and neglect had limited my father's education to finishing fourth grade. He had been born on the St. Croix Reservation, a Chippewa Indian reservation in Wisconsin. After his mother's death, he was taken to an orphanage in Chicago and was adopted by a cruel woman. At the age of ten, Papa ran away and lived on the streets of Chicago until he moved, at the age of nineteen, to what was to become our island home. Mama was Swedish, and her childhood paralleled that of my father's: she too was an abused orphan. Mama escaped her abuse by marrying Papa at sixteen and moving to the island. She dropped out of school the summer before her junior year.

What does this have to do with my low math achievement? It has everything to do with it. I remember watching Papa struggle to complete computations and then seeing him hand the paper to Mama saying, "Ruth, check it." From early on, I knew that Mama was better at math than Papa - she knew her times tables and long division. The problem was, Mama believed that she was mathematically incompetent. However, she and Papa each valued reading. Evenings were spent reading books aloud, and Mama loved to write. But, I do not remember Mama or Papa ever talking positively about math, ever flashing a flash card, or ever posing a math problem to be solved merely for practice.

It wasn't that my childhood was entirely void of math. My brothers and I were financial entrepreneurs. We speared carp and sold them to the old black men fishing across from our island. We caught worms, crabs, and halgermites and sold them for bait at a gas station, we planted seeds and sold the flowers, baked cookies and sold them door to door. For young children, our arithmetic skills were incredible. We learned very early how to make an honest profit from an investment - Mama and Papa taught us to be honest,

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never to steal and never to accept charity. Poverty taught us to be self-sufficient problem-solvers.

Our rich situated learning experiences should have prepared us to become successful mathematicians. However, something broke down and that something was our formal education. Being labelled "river rats" and "half-breed trash", prompted my older sister and two brothers to drop out of high school. My kid brother, Ted, and I graduated, but my graduation seemed to have happened to me, as though I had nothing to do with it. I preferred to stay home rather than go to school. I preferred wading the river, searching for bird's nests, sitting and drawing, helping Mama garden and cook. School was a place where I had to be tough, ready to fight when someone teased. I remember Ted being pantsed on the playground by a group of kids who had bet that we were too poor to buy underwear. I grabbed a baseball bat and swung it violently at the boys who were pulling at his pant legs. I was not going to let them learn that they were right.

No, I was never part of the system, and mathematics wasn't important to me because the system wasn't important. Even now, as I write these words, deep down, I feel the same.

It is very easy for me to relate my narrative to Witthuhn's study. I feel that I understand how poverty impacts on math performance. More often that not, today's children of poverty have parents, like mine, who are alienated from the system, and their alienation influences the level of math assistance and support they are capable of giving. It's not that they are inferior parents,

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it's just that poverty has marginalized them for so long that it has become a way of thinking, and their children are not cognitively inferior, at Piaget's concrete stage of development, it's just that their experiences are drastically different from middle class children whose parents have internalized a belief in "manifest destiny". It is no mystery why middle class children exhibit linear computational skills, after all, their's are the parents who buy number recognition books at the grocery store for their toddlers, who flash number facts to their third and fourth graders, and who make certain that their high schoolers have the right math courses to qualify for college. On the other hand, it is no mystery why, even today, I feel incompetent with linear computation yet competent with spatial skills. My family culture simply involved me with one rather than the other: following Papa's map to find where traps had been set was something that my brother and I were expected to do; building tree huts with pulley systems to lower or raise oneself was play; hiking far into unfamiliar woods and finding our way back was challenging.

I recognize that my unique family culture was incredibly rich with positive learning experiences, and I fear that the majority of children in poverty today are not as fortunate. However, the unique lived experiences of these children must not be devalued. Instruction must be built upon these experiences not only because cognitive psychologists recommend this as an effective way to help children construct schema (Carpenter & Moser, 1983; Case, 1983; Case & Bereiter, 1982; Riley et al., 1983)), but because this is a way for children to learn to appreciate and/or understand their respective cultures and, in turn, to appreciate and understand themselves. Leap's recommendation to provide remediation rather than instruction to Indian children reflects an insensitivity to what it means to be Indian and to what it means to be poor. His recommendation is top-down remediation, not culture-based instruction.

My family culture devalued materialism, competition, and greed. My siblings and I were taught to share, to get by on little, and to love learning. Yet, we were and are identified by standard achievement instruments as math low achievers. But, I am wondering what this really means. I am wondering what level of mathematics is really important for success, and just what it means to be successful? These are issues that American Indians must resolve before they buy into the materialism of mainstream America. There is no question of potential competence. The questions of importance are, What should Indian math look like? What purposes should it serve? and How will this form of math education be equitably distributed?

Summary

Within this paper, a brief literature review documented the existence of low math achievement among American Indians, two studies pertaining to causes of the problem were analyzed, and a personal narrative was shared. The intention behind integrating these texts was to illuminate the need for researchers to collaborate, to integrate efforts and share in discourse, to develop a united front to pursue resolution of the "Indian mathematics problem". The conclusions drawn at the end of the narrative suggest that the resolution might appear quite different from what educators of the middle class dominant society prescribe, and then, it might appear quite similar. After all, as Mother Earth's resources diminish, survival is what all ethnic groups will be concerned with, and linear thinkers might learn something from spatial thinkers.

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