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# Standards-Based Mathematics Reforms and Mathematics Achievement of American Indian/Alaska Native Eighth Graders[1]

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**Abstract**
Using the NAEP nationally-representative data collected from eighth-graders, we investigated the relative exposure of American Indian/Alaska Native (AIAN)

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students to mathematics teachers who are knowledgeable about standards, participate in standards-based professional development, and practice standards-based instruction; American Indian/Alaska Native student reports of standards-based classroom activities; and how student reports of classroom activities and teacher reports of their knowledge, professional development, and practices are associated with mathematics achievement of American Indian/Alaska Native students. We found that AIAN students had among the lowest exposure to teachers who reported they were knowledgeable about standards, who participated in standards-based professional development, and who practiced standards-based instruction. In addition, AIAN students were less likely than African American and Latino students to report that they experienced standards-based classroom activities. Our data showed that teacher reports of standards-based knowledge and practice of standards-based instruction were not significantly associated with mathematics achievement of AIAN students. However, student reports of classroom activities characterizing standards-based instruction was associated with higher mathematics achievement of AIAN students.
Keywords: American Indian/Alaska Native Students; National Assessment of Educational Progress (NAEP); standards-based reform; student achievement.

**Reformas de matemáticas basadas en estándares y aprendizajes matemáticos entre estudiantes de octavo grado indios-americanos / nativos de Alaska**

**Resumen**
Usando datos representativos a nivel nacional del estudio NAEP, recogidos con alumnos de octavo grado, investigamos la exposición relativa de estudiantes indios-americanos / nativos de Alaska (IANA) a profesores de matemáticas que conocen los estándares de instrucción, participan de capacitaciones basadas en los estándares de instrucción y enseñan basándose en los estándares de instrucción; Los informes sobre actividades del aula basados en los estándares y los informes de los profesores sobre sus conocimientos, la formación profesional y las prácticas están relacionadas con los aprendizajes de matemáticas de los estudiantes indios-americanos / nativos de Alaska. Encontramos que los estudiantes IANA están entre los grupos con niveles más bajos de exposición a maestros con conocimientos sobre los estándares, que participan de capacitaciones basadas en los estándares y que enseñan basándose en los estándares instrucción; Además, los estudiantes IANA tenían menos probabilidades que los estudiantes afro-americanos y latinos a reportar que recibieron enseñanza basada en los estándares instrucción. Nuestros datos muestran que los informes de docentes basadas en estándares conocimiento y práctica de instrucción basadas en estándares conocimiento no se asociaban significativamente con el aprendizaje de matemáticas entre estudiantes IANA. Sin embargo, los informes de los estudiantes que caracterizan las actividades de aula como basadas en los estándares de instrucción se asociaron con un aprendizaje mayor de matemáticas entre los estudiantes IANA.
Palabras clave: estudiantes Indios Americanos / Nativos de Alaska; Evaluación Nacional del Progreso Educativo (NAEP); reforma basada en estándares sobre los aprendizajes de los estudiantes.

## Introduction

Researchers and educators serving American Indian/Alaska Native (AIAN) students have debated for more than two decades about whether standards-based reforms benefit AIAN students. On one hand, researchers and educators support standards-based reforms because such reforms focus not only on assessing these students' academic achievement, but also on developing a support system to guarantee AIAN students' opportunities to learn (Fox, 2000). Researchers have also pointed out that constructivist instruction supported by the major national and state standards is consistent with American Indian ways of teaching (Fox, 2000; Hankes & Fast, 2002; Nelson-Barber & Estrin, 1995). On the other hand, opponents and critics of standards-based reforms argue that the culturally-inappropriate nature of standards and assessments based on mainstream values does not benefit AIAN students, and they argue further that standardization is an invasion of Native American sovereignty (Lomawaima & McCarty, 2002; McCarty, 2002; Pewewardy, 1998).

Complicating this debate is the lack of empirical studies concerning the impact of standards-based reforms on AIAN students' learning. The knowledge produced by the existing research focused on tribally-run schools in which only 7% of American Indians or Alaska Natives are enrolled (Demmert, 2001; Strang & von Glatz, 2001). Among AIAN students, 93% attend regular public schools (Freeman & Fox, 2005). Despite this fact, few studies have analyzed nationally representative data to examine the relationship between teacher practices and learning of AIAN students in public schools. Researchers and educators have called not only for the examination of AIAN students' learning environment and opportunities, but also the examination of effective conditions for promoting their learning based on nationally representative data (Demmert, 2001; Fox, 2000; Strang & von Glatz, 2001).

The student, teacher, and school survey dataset in the National Assessment of Educational Progress (NAEP) is one of the most comprehensive datasets containing information from a representative sample of AIAN students attending public schools, their teachers, and schools. The focus of this study is teacher knowledge, preparation, and practices aligned with standards-based reforms, rather than district or state-level policies and contexts on standards-based reforms. We address three research questions. First, how does American Indian/Alaska Native students' exposure to mathematics teachers who are knowledgeable about standards, participate in standards-based professional development, and practice standards-based instruction (based on teacher survey) differ from that of White, African American, and Latino students? Second, how does student report of standards-based classroom activities among American Indian/Alaska Native students differ from that of White, African American, and Latino students? Finally, how are teacher-reported standards-based knowledge, professional development participation, practice of standards-based instruction, and student-reported standards-based classroom activities associated with mathematics achievement of American Indian/Alaska Native students compared to the achievement of White, African American, and Latino students?

## Background

### Current Educational Conditions of American Indian/Alaska Native students

The federal government currently recognizes 562 American Indian and Alaska Native tribes (Bureau of Indian Affairs, 2004). These tribes are considered to have the power of self-government,

the zoning of land, and the exclusion of people from tribal territories with their "domestic dependent nation status" (Freeman & Fox, 2005, p.10). As of 2000, Cherokee and Navajo nations constitute the two largest American Indian tribes in the U.S. (Freeman & Fox, 2005). In 2002, 624,000 American Indian or Alaska Native students were enrolled in public elementary and secondary schools, which constitutes 93% of all AIAN students in the U.S. (Freeman & Fox, 2005). American Indian and Alaska Native students constitute 1.2% of the total student enrollment in public schools (Freeman & Fox, 2005). This percentage is smaller than Australia, where 4% of students are categorized as Indigenous students (Australian Bureau of Statistics, 2006), and New Zealand, where 21% of students are Māori students (New Zealand Ministry of Education, 2006). Of all American Indian and Alaska Native students in public schools, 56% attend schools where less than 25% of the student population is American Indian or Alaska Native, and 38% attend schools in rural areas (Freeman & Fox, 2005).

In addition to the AIAN students in public schools, the Bureau of Indian Affairs (BIA) directly operates or provides grant or contract support for 185 elementary and secondary schools that serve 46,000 AIAN students (Freeman & Fox, 2005,). According to the 2005–2006 Common Core Data (CCD), the states with the largest population of AIAN students as a percentage of the total student population are Alaska (26.6%), Oklahoma (18.9%), Montana (11.3%), New Mexico (11.1%), South Dakota (10.5%), North Dakota (8.6%), and Arizona (6.6%) (National Center for Educational Statistics, 2007).

The NAEP 2003 and 2005 reports showed that AIAN students in 4th and 8th grades had lower reading and mathematics scores than White and Asian/Pacific Islander students; while the scores of AIAN students were not significantly different from Latino students, they scored higher than their African American peers (Freeman & Fox, 2005; Rampey, Lutkus, & Weiner, 2006). However, college enrollment for 18–24 year-old AIAN students is 18%, the lowest percentage compared to White (42%), Asian/Pacific Islander (60%), African American (32%), and Latino (24%) students (Freeman & Fox, 2005). In the school year 2000–2001, dropout rates among AIAN 9th to 12th graders were 7.5%, a higher percentage than for any other ethnic groups (U.S. Department of Education, 2003a). These statistics show the need to examine educational conditions and opportunities for AIAN students and to identify effective instructional conditions for improving AIAN students' achievement and academic advancement.

**Past and Current Educational Reforms for American Indian/Alaska Native Students**

Multiple federally-sponsored reports have documented that the federal government's education of AIAN students over more than the last 100 years has not been successful. The Meriam Report (Meriam et al., 1928) and the Kennedy Report (U. S. Senate Special Subcommittee on Indian Education, 1969) both pointed out that Boarding schools and Day Schools aimed to "civilize" and "assimilate" AIAN students into a Christian America and that the education conditions were poor (see also Barnhardt, 2001; Noel, 2002). Both reports called for Indian communities' involvement in school education and curricular integration of Indian language and culture.

In 1972, the Indian Education Act authorized grants to meet the needs of AIAN students in public schools (Barnhardt, 2001). The Indian Self-Determination and Education Assistance Act passed three years later, and it aimed to increase local control of the BIA Day Schools, including the curriculum design and the hiring of teachers (Barnhardt, 2001). Despite these laws, after 20 years the Indian Nations At Risk Task Force (1991) identified Indian nations as "at risk" because schools discouraged the use of Native languages, which led to the erosion of Native culture and language, and to high dropout rates and negative attitudes toward school among American Indian students.

Under the No Child Left Behind Act of 2001, all public schools are required to follow the state standards and participate in state assessment and be held accountable for the assessment results. A case study by Jester (2002) described a district's standards-based reform in Alaska where Alaska Native students were placed into a nonacademic track under a "no-failure" system. This program promoted a civilization-savagism paradigm, which legitimized their academic failure and promoted the stereotype of unhealthy/inferior homes among Alaska Natives.

While BIA schools can choose either to follow the national or state standards or develop their own standards that are as stringent as the national or state standards, most schools chose not to develop their own standards (Fox, 2000). The BIA (2005) developed *American Indian Content Standards*, and the Assembly of Alaska Native Educators (1998) developed *Alaska Standards for Culturally-Responsive Schools*, yet, little is known about how widely-used these standards are in public schools. The National Indian Education Study (Stancavage et al., 2006) showed that only 6% of eighth-grade students are in classrooms with mathematics teachers who use American Indian/Alaska Native content or cultural standards developed by the state or by a local education agency or council "to some extent" or "a lot." In contrast, 92% of students are taught by teachers who use state content standards for mathematics "to some extent" or "a lot." In this context of standards-based reforms and accountability, it is necessary to examine whether the current direction in the standards-based reforms is effective in improving learning of AIAN students.

## Theoretical Framework

The National Council of Teachers of Mathematics (NCTM) standards as well as many state and district standards are guided by constructivist theory (National Council of Teachers of Mathematics, 2000). Constructivist theory explains the cognitive dimension of student learning as a process of constructing meaningful representations and of making sense of one's experiential world (von Glasersfeld, 1995, 1996). Through this process, students' errors are a means of gaining insight into how they are organizing their experiential world. Constructivist theorists argue that their theory of learning is universal to all children across cultural and linguistic boundaries (Carey, Fennema, Carpenter, & Franke, 1995). Cognitively Guided Instruction (CGI) is a strategy developed by Fennema, Carpenter, and Peterson (1992) based on the constructivist theory (also see Carpenter, Fennema, & Franke, 1996). Researchers of American Indian education have successfully applied CGI to American Indian students (e.g., Hankes, 1998). Constructivist theory promotes the professional movement to shift the focus from teacher-centered instruction to student-centered instruction. Students learn mathematics only through the teachers' effort to understand students' daily experiences and connect those experiences with school mathematics. Therefore, constructivist theory encourages teachers to pay more attention to each student's experiences and culture, including those of AIAN students. If standards-based reforms encourage teachers to understand the importance of student-centered instruction and to teach in a way that connects mathematics contents to the daily experiences of AIAN students, these reform movements should lead to improved student achievement among AIAN students.

## Standards-Based Mathematics Knowledge and Professional Development

Several survey studies have examined the impacts of teacher knowledge and professional development activities on teacher practices of student-centered, constructivist instruction (Cohen & Hill, 2000; Desimone, Porter, Garet, Yoon, & Birman, 2002; Garet, Porter, Desimone, Birman, &

Yoon, 2001). Based on a survey of 975 teachers in California, Cohen and Hill (2000) found that mathematics teachers who are familiar with leading reform ideas and who participated in professional development on standards-based math curriculum were more likely to practice reform-oriented instruction. Based on a longitudinal survey of 207 mathematics and science teachers in five states, Desimone et al. (2002) further showed that standards-based professional development is effective in improving teacher practice of higher order instruction especially when the activities involve active learning in which teachers are not passive recipients of information, and when reform type of activities such as teacher study group and mentoring are provided (see also Garet et al. 2001). Despite the empirical knowledge on the positive impacts of standards-based knowledge and professional development on teacher practice, little is known about how they impact student achievement. In addition, few studies have examined whether and how the relationship between standards-based knowledge and professional development and student achievement differ by ethnic groups.

**Standards-Based Mathematics Instruction**

The positive impacts of standards-based mathematics instruction on student learning have been empirically demonstrated through qualitative and quantitative studies on CGI (Carey et al., 1995; Carpenter & Fennema, 1992; Fennema et al., 1996; Knapp & Peterson, 1995; Villasenor & Kepner, 1993). For example, Villasenor and Kepner (1993) conducted an experimental study of impacts of CGI workshop on mathematics instruction and student arithmetic performance in ethnically-diverse urban classrooms (57–99% African American, Latino, and AIAN students). They found that teachers in the treatment group applied instruction focused on student thinking process more frequently than did teachers in the comparison group . They also found that their students demonstrated a significantly greater improvement in arithmetic word problems than did their counterparts. These findings are consistent with the study that examined CGI's effectiveness on African American students' mathematics achievement in Maryland (Carey et al.,1995; Carpenter & Fennema, 1992).

Only one published study about American Indian students has examined the impact of standards-based instruction on student learning. Based on semi-structured interviews of an Oneida kindergarten teacher and assessment of problem-solving performance of her 17 Oneida kindergarteners in Wisconsin, Hankes (1998) examined the effectiveness of CGI. The teacher who participated in two years of CGI training identified the similarity between CGI and American Indian pedagogy, and reported that the use of CGI fostered her own ability to gain a better understanding of mathematics and how the children develop problem-solving capabilities. In addition, the Oneida kindergarteners taught using CGI demonstrated a higher problem-solving ability (Hankes, 1998). An important finding in this study was the fact that the Oneida teacher did not see a disjuncture between constructivist instruction and the practice of American Indian instruction. Hankes and Fast (2002) explained that constructivist instruction and Native American pedagogy share the same pedagogical principles that support the teacher as a facilitator employing indirect rather than direct instruction, problem solving based on what makes sense, problem-based instruction with problems situated in the culture and lived experiences of the learner, cooperation rather than competitive instruction, and time-generous rather than time-dependent instruction. If mathematics teachers of AIAN students practice these principles under standards-based reforms and connect mathematics content with AIAN students' culturally-embedded daily experiences, they should be able to enhance the classroom learning experience of these students.

The 2000 data from the National Assessment of Educational Progress (NAEP) offer a unique opportunity to investigate the relationship among standards-based teacher knowledge, professional development, and instructional practice, and mathematics achievement of AIAN students, compared with other ethnic groups. An examination of the association among these factors using nationally-representative data is an important step towards understanding the impacts of standards-based reforms on learning of AIAN students.

## Methods

### Data

The National Assessment of Educational Progress (NAEP), also referred to as the Nation's Report Card, is the only nationally and state representative data and continuing assessment of student achievement in various subject areas in the U.S. Since 1969, the National Center for Education Statistics (NCES) in the U.S. Department of Education has conducted assessments in reading, mathematics, science, writing, U.S. history, civics, geography, and the arts, and collected background information of students, teachers, and principals using survey questionnaires. The NAEP 2000 mathematics dataset was selected for this study instead of the NAEP 2003 or 2005 datasets because these more recent datasets did not include items on teacher reports of constructivist instruction and knowledge of standards. Mathematics data were chosen because mathematics has been a focus of standards-based reforms, and it is a subject for which the No Child Left Behind Act holds districts and schools accountable based on the results of state standardized tests. In addition, mathematics is a core subject that often determines students' future academic trajectories and success.

The NAEP 2000 national mathematics data on eighth graders and their teachers and principals in public schools were collected based on a stratified multi-stage sampling method to represent secondary schools in the U.S. The public school sampling frame was constructed from three sources which include the 1997–98 NCES Common Core of Data (CCD) Public Elementary and Secondary School Universe file, the Quality Education Data (QED), and the Department of Defense Education Activity (DoDEA) website. Based on the stratification of region of the country, extent of urbanization, percentage of minority enrollment, and median household income, schools serving eighth-graders were randomly selected within each stratification group, and students were randomly selected within schools.[2] To ensure the representation of major subgroups, schools with large minority populations were oversampled. A sampling weight was used in all the analyses presented here to adjust for the unequal probabilities of selection. Selected eighth-graders participated in mathematics assessment and completed a background questionnaire. All the mathematics teachers of sampled eighth-graders were identified and completed a teacher questionnaire that includes background information and data on standards-based knowledge, professional development, and instructional practice. School principals of sampled schools also provided background information including poverty level and school size.

This analysis includes data in the overall sample collected from 213 AIAN eighth-grade students and 134 eighth-grade mathematics teachers in 116 public schools. Data from nationally representative samples of 9,278 White students, 2,385 African American students, and 2,498 Latino students were available for comparison with AIAN students' achievement, background

[2] Classroom was not a sampling unit in the NAEP. Therefore, it is not possible to identify the students who belong to the same classrooms as American Indian/Alaska Native students.

characteristics, teacher and school background characteristics, and their exposure to standards-based reform factors (teachers with standards-based knowledge, professional development, and practice). For the analysis of the relationship between standards-based reform factors and student achievement, the data from AIAN students were compared with other students who had the same teachers in the sample as AIAN students: 962 White students, 292 African American students, and 266 Latino students. Of the set, 171 AIAN students had complete data for all predictor and control variables, and 171 students from the other ethnic groups were randomly selected to match the sample size with AIAN students, and analyzed as the comparison groups.

**Measures**

*Mathematics achievement.* Eighth graders' mathematics achievement level was measured by a standardized test of both basic skills and problem-solving ability. Each examinee took only a subset of the test items in a given area and item response theory (IRT) was employed to create a scale to represent students' achievement levels.[3] Five plausible values were imputed as the best estimates of each student's performance, based on the test results and the background information for all examinees with similar demographic characteristics and identical response patterns. All five values were analyzed as student mathematics achievement in this study using the software developed by American Institutional Research (available free from http://am.air.org/).

*Standards-based teacher knowledge, professional development, and instruction*. We developed four measures of standards-based knowledge, professional development, and instruction based on teacher survey and student survey. Three measures developed from teacher survey included the teacher report of their knowledge of standards, their participation in standards-based professional development, and their use of standards-based instruction. We developed another measure of standards-based instruction premised on student report of standards-based classroom activities. Two measures of standards-based instruction premised on teacher and student reporting were used to assess the difference in the relationship between standards-based instruction and student achievement based on the measurement type. Teachers' self report is most commonly used to measure instructional practices in large-scale survey research. While the potential gap between teacher perception of his/her practice of constructivist instruction and the actual nature of instruction observed by researchers has been documented (Burstein et al., 1995; Cohen, 1990), the validity of composite survey measure of standards-based mathematics instruction was empirically proven by a correlation as high as .85 with a parallel composite based on classroom observations in Mayer (1999).

What is not known is the usefulness of student-reported measures of instructional practices. Major large-scale databases including the NAEP and the Trends in International Mathematics and Science Study (TIMSS) often gather student reports of their experiences in mathematics classrooms. Based on the logic that the impact of constructivist instruction on student achievement is likely mediated by student perception and experience of learning activities, there is a methodological significance in investigating how a composite measure of student-reported constructivist instruction is associated with mathematics achievement of AIAN students. The description of each composite measure is provided below.

For the teacher report of standards-based knowledge, NAEP surveys asked mathematics teachers, "How knowledgeable are you about: 1) the National Council of Teachers of Mathematics

[3] See the NCES report by Roger, Kokolis, Stoeckel, and Kline (2002) for details on item response theory (IRT) and assessment of mathematics achievement.

(NCTM) Curriculum and Evaluation Standards for School Mathematics, 2) your state's math standards, and 3) your local math standards?" For item 1, their responses were coded as 1 = little or no knowledge, 2 = somewhat knowledgeable, 3 = knowledgeable, and 4 = very knowledgeable. The other two items were coded as 1 = little or no knowledge, 2 = somewhat knowledgeable, and 3 = very knowledgeable. The latter two items were multiplied by 1.33 to standardize the coding, and the mean of all three is used as a composite measure of mathematics teachers' knowledge of mathematics standards (Cronbach's alpha index: Overall = .78, AIAN = .87, White = .69, African American = .86, Latino = .87).

For the teacher report of standards-based professional development, NAEP asked mathematics teachers, "Have you ever studied: 1) problem solving in mathematics, 2) use of manipulatives (e.g., counting blocks or geometric shapes) in mathematics instruction, and 3) understanding students' thinking about mathematics, either in college or university courses or in professional development workshops or seminars."[4] The sum of the three variables is used as an index of standards-based professional development that ranges from 0 to 3 (Kuder-Richardson 20 reliability index for dichotomous data: Overall = .55, AIAN = .53, White = .58, African American = .53, Latino = .50).[5]

For the teacher report of standards-based instruction, NAEP asked mathematics teachers to indicate the frequency at which their students in class do each of the following activities: solve problems with other students, write a few sentences about how to solve a mathematics problem, write reports or do mathematics projects, discuss solutions to mathematics problems with other students, work and discuss mathematics problems that reflect real-life situations, work with objects like rulers, and talk to the class about their mathematics work. Their responses for each were coded as 1 = never or hardly ever, 2 = once or twice a year, 3 = once or twice a month, and 4 = once or twice a week. The average of the seven items were computed as a composite measure of constructivist instruction reported by mathematics teachers (Cronbach's alpha index: Overall = .65; AIAN = .60, White = .63, African American = .82, Latino = .58).

For the student report of standards-based classroom activities, NAEP asked eighth-grade students, "When you do mathematics in school, how often do you: 1) solve mathematics problems with a partner or in small groups, 2) use measuring instruments or geometric solids, 3) write about solving a math problem, and 4) talk with other students during class about how you solved mathematics problems?" Their answers were coded as 1 = never or hardly ever, 2 = 1–2 times a month, 3 = 1–2 times a week, and 4 = almost everyday. The average of the four variables were computed as a composite measure of student experiences of standards-based classroom activities in mathematics classrooms (Cronbach's alpha index: Overall = .55, AIAN = .59, White = .53, African American = .50, Latino = .63).

*Individual student, teacher, and school background.* Students' gender was coded dichotomously. For parental education, NAEP asked students to choose from four choices (1 = did not finish high school, 2 = graduated from high school, 3 = some education after high school, 4 = graduated from college) for each parent, and the average of mother and father education levels was used as an index of parents' education level. For teacher experience, NAEP asked teachers, "Counting this year, how many years in total (including part-time teaching) have you taught math?"

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[4] While these items measured both pre-service and in-service education activities, we decided to use the term *professional development* to include broad learning opportunities that cover both pre-service and in-service activities. Previous survey studies on professional development also used this broad definition to include pre-service learning opportunities (Desimone et al. 2002; Garet et al. 2001).

[5] These Cronbach's alpha indices are within the range of modest reliability (Ary, Jacobs, Razavieh, & Sorensen, 2006).

The answer was re-coded as 0=less than 3 years and 1=3 or more years.[6] For content background, NAEP asked teachers if they held an undergraduate or graduate degree in mathematics.[7] Their answers to these questions were coded as 1=undergraduate or graduate major in mathematics and 0=no. NAEP also asked teachers if they held an undergraduate or a graduate degree in mathematics education. Their answers to these questions were coded into one variable with 1=undergraduate or graduate major in mathematics and 0=no. The total number of students enrolled in the school was used as school size. The NAEP data reported by principals on the percentage of students in their schools eligible to receive a free or reduced-price lunch through the National School Lunch Program were coded as 1 = 0%, 2 = 1–5%, 3 = 6–10%, 4 = 11–25%, 5 = 26–50%, 6 = 51–75%, 7 = 76–99%, and 8 = 100%.

**Analysis**

*How does American Indian/Alaska Native students' exposure to mathematics teachers who are knowledgeable about standards, participate in standards-based professional development, and practice standards-based instruction (based on teacher survey) differ from that of White, African American, and Latino students?* To answer the first research question, we conducted ANOVA tests of overall mean differences among the four ethnic groups and t-tests of mean difference between two groups (all the combinations) in standards-based reform variables incuding teacher-reported knowledge of NCTM, state, and district standards, teacher-reported participation in standards-based professional development, and teacher-reported practices of standards-based instruction.

*How does student report of standards-based classroom activities among American Indian/Alaska Native students differ from that of White, African American, and Latino students?* To address the second question, we conducted ANOVA tests of overall mean differences among the four ethnic groups, and t-tests of mean differences between two groups (all the combinations) in student report of classroom activities aligned with standards-based instruction.

*How are teacher-reported standards-based knowledge, professional development participation, practice of standards-based instruction, and student-reported standards-based classroom activities associated with mathematics achievement of American Indian/Alaska Native students in comparison to White, African American, and Latino students?* For the final question, we conducted multiple regression analyses with the dependent variable of mathematics score (five plausible values based on IRT) using the AM software. While the data are hierarchical in nature, the number of students per teacher was 1.6 and the number of teachers per school was 1.2 for AIAN students. Due

[6] Many empirical studies have shown a significant and positive relationship between number of years and student achievement (Greenwald, Hedges, & Laine, 1996; Rice, 2003). However, the relationship is not linear. Teachers' effectiveness in improving student achievement appears to increase most in the first three years of teaching, but no major improvement in their effectiveness was observed after three years of teaching experience (Boyd, Grossman, Lankford, Loeb, & Wyckoff, 2006; Rice, 2003; Rivkin, Hanushek, & Kain, 2005).

[7] Several syntheses of empirical studies have identified subject matter knowledge measured by subject major as significantly associated with higher student achievement or greater achievement gains (Darling-Hammond & Youngs, 2002; Rice, 2003; Wayne & Youngs, 2003; Wilson, Floden, & Ferrini-Mundy, 2001, 2002). For example, using the NELS:88 data, Goldhaber and Brewer (1997, 2000) examined the impact of subject major or degree on student achievement gains among 10th and 12th graders and found that those students who were taught mathematics by teachers with an undergraduate or graduate mathematics major made greater achievement gains than those who were taught mathematics by teachers with a non-math major or degree (see also Rowan, Chiang, & Miller, 1997).

to the small within-teacher and within-school variations, we disaggregated all the variables at the student level and conducted multiple regression analyses instead of using Hierarchical Linear Modeling.

We included seven variables: student gender, parents' education level, years of mathematics teaching, mathematics major of the teacher, mathematics education major of the teacher, school size, and poverty level as control variables. We examined four models of the relationship between standards-based reform variables and student achievement with each of the four standards-based reform variables. These models were examined separately for AIAN students, White students, African American students, and Latino students to compare the relationships between standards-based reform factors and student achievement in mathematics.

## Results

Before we examined the level of students' exposure to standards-based reform factors, we examined background characteristics of AIAN students, their teachers, and the schools they attend. Table 1 shows comparisons of mathematics achievement, parents' education level, percentage of students taught by teachers with a mathematics major, percentage of students taught by teachers with a mathematics education major, school size, and school poverty level between AIAN students and White, African American, and Latino students. ANOVA analyses were conducted for mathematics achievement, parents' education level, school size, and school poverty level, and chi-square analyses were conducted for the percentages taught by teachers with a mathematics or mathematics education major. The notes under the table show the results of t-tests and chi-square tests for all combinations of comparisons of two ethnic groups.

During 2000 when the data were collected, AIAN students performed significantly lower in mathematics than White students, but significantly higher than African American students. There was no significant difference between AIAN students and Latino students.[8] Parents' education level of AIAN students was significantly lower than that of White students, not significantly different of that of African American students, but significantly higher than that of Latino students. We also observed major variations in the percentage of students taught mathematics by teachers with a mathematics major or mathematics education major. Only 27% of AIAN students were taught mathematics by teachers who majored in mathematics in undergraduate or graduate degree. This percentage was significantly lower than any other groups. 44% of White students, 36% of African American students, and 33% of Latino students were taught by teachers with a mathematics major, and the percentage of White students taught by math majors was significantly higher than that of African American and Latino students. Of all AIAN students, 21% were in math classes taught by teachers who majored in mathematics education for their undergraduate or graduate degrees. Again, this was the smallest among the four groups, although there was no statistically significant difference with Latino students (22%). Of all White students, 36% were taught by teachers with mathematics

[8] The difference in mathematics achievement among ethnic groups was also examined by different school location (rural, suburban, urban) and parent education level (low, middle, high). The same pattern of American Indian/Alaska Native students achieving significantly lower than White students existed across various school location and parent education level. However, the difference between American Indian/Alaska Native students and African American or Latino students was not consistent across different locations and parent education levels. In rural schools and among students with middle and high levels of parent education, there was no significant difference in mathematics achievement among American Indian/Alaska Native students, African American students, and Latino students.

education majors, a significantly higher percentage than the 28% of African American students taught by mathematics education majors.

Table 1
*Comparison of Individual, Teacher, and School Characteristics between American Indian/Alaska Native students and Other Students*

| Variable | AIAN[a] | White | African American | Latino | Test statistic |
|---|---|---|---|---|---|
| *Individual Characteristics* | | | | | *F* value |
| Math Achievement[b] | 254.1 | 285.8 | 247.0 | 252.9 | 1172.0* |
| Parents' Education Level[c] | 2.7 | 3.0 | 2.8 | 2.5 | 177.0* |
| *Teacher Characteristics* (% of students taught by teachers with major) | | | | | $\chi^2$ value |
| Math Major[d] | 27.0% | 44.3% | 35.5% | 33.2% | 146.3* |
| Math Education Major[e] | 21.2% | 35.5% | 27.7% | 21.8% | 190.7* |
| *School Characteristics* | | | | | *F* value |
| School Size[f] | 616.3 | 740.9 | 1018.4 | 996.8 | 70.5* |
| Poverty Level[g] | 5.8 | 3.9 | 5.6 | 5.3 | 1208.8* |
| Total Sample Size | 213 | 9,278 | 2,385 | 2,498 | |

* p<.001
Notes: [a] American Indian/Alaska Native students
[b] First plausible value. White > AIAN, Latino > African American
[c] Mean of mother and father's education levels and coded as 1 = did not finish high school, 2 = graduated from high school, 3 = some education after high school, and 4 = graduated from college or above.
White > African American, AIAN > Latino
[d] White > African American, Latino > AIAN
[e] White > African American > Latino, AIAN
[f] African American, Latino > White, AIAN
[g] Percentage of students receiving free or reduced lunch coded as 1 = 0%, 2 = 1–5%, 3 = 6–10%, 4 = 11–25%, 5 = 26–50%, 6 = 51–75%, 7 = 76–99%, 8 = 100%.
AIAN, African American > Latino > White

The mean size of schools (number of students) attended by AIAN students was 617, which is the smallest compared to 741 for White students, 1019 for African American students, and 997 for Latino students. The school sizes for African American and Latino students were significantly larger than those of AIAN and White students. The small school size of AIAN students is explained by the fact that 41% of AIAN students in the sample were attending rural schools.

Poverty level of the school was measured by the percentage of students receiving free or reduced lunch and the coding ranged from 1 (0%) to 8 (100%). The poverty level of the schools attended by AIAN students was the highest (5.8) among the four groups, followed by African American students (5.6). The poverty level of schools attended by Latino students (5.3) was significantly lower than that of AIAN and African American students. The poverty level of schools attended by White students (3.9) was significantly lower than any other group.

These data show that while mathematics achievement of AIAN students was not lower than other ethnic minority groups, they were the least likely to be taught mathematics by teachers with a mathematics major or mathematics education major, and they were the most likely to attend small

schools and high-poverty schools. Students' opportunities to be taught by teachers with a mathematics-related major significantly differed across ethnic groups, with White students receiving better opportunities than ethnic minority students. Combined with the gap in parents' education level and possible lack of school resources in high-poverty and small schools, this opportunity gap is likely to contribute to widening the achievement gap.

**Student Exposure to Teachers with Standards-based Knowledge, Professional Development Activities, Standards-Based Instruction (Teacher Report)**

What are the levels of students' opportunities to be taught by teachers with standards-based knowledge, who participate in standards-based professional development activities, and who practice standards-based instruction? The upper part of Table 2 (on the next page) presents comparisons of teacher report of standards-based knowledge, professional development, and practice among national samples of four ethnic groups. AIAN students were less likely to be taught by mathematics teachers who reported that they were knowledgeable about the NCTM standards, state standards, and local standards than any other groups. They were also less likely to be taught by mathematics teachers who studied problem solving, used manipulatives, and student mathematical thinking in pre-service or in-service education than White students and Latino students. There was no significant difference between AIAN students and African American students in their teachers' report of participation in standards-based professional development activities.

Teachers of AIAN students and White students were significantly less likely than teachers of African American students and Latino students to report that they use standards-based instruction (e.g. write reports or do mathematics projects, work and discuss mathematics problems that reflect real-life situations). Teachers of African American students reported a higher level of use of standards-based instruction than those of Latino students. These data show that, in general, AIAN students have the lowest level of opportunity to be taught by teachers who report that they are knowledgeable about standards, they participate in standards-based professional activities, and they practice standards-based instruction.

**Student Report of Standards-Based Classroom Activities**

How does the level of student participation in standards-based classroom activities differ among the four ethnic groups? This measure was created based on student report, and it measures student perception of classroom activities more accurately than teacher report. While we cannot compare the values of student-reported standards-based classroom activities and teacher-reported standards-based instruction due to the difference in the coding schemes and the number of items used to create the composite variables, we can compare the pattern of differences among ethnic groups in these two measures.

Table 2
*Comparison of Standards-Based Reform Factors between American Indian/Alaska Native students and Other Students*

| Sample and Variable | AIAN[a] | White | African American | Latino | *F* value |
|---|---|---|---|---|---|
| **National Sample** | | | | | |
| *Teacher Reports* | | | | | |
| Standards-Based Knowledge[b] | 2.76 | 3.12 | 3.13 | 3.10 | 26.42* |
| Standards-Based Professional Development[c] | 2.32 | 2.53 | 2.43 | 2.52 | 17.99* |
| Standards-Based Instruction[d] | 2.42 | 2.48 | 2.61 | 2.54 | 51.89* |
| *Student Report* | | | | | |
| Standards-Based Classroom Activities[e] | 2.24 | 2.22 | 2.44 | 2.36 | 68.04* |
| Sample Size | 213 | 9,278 | 2,385 | 2,498 | |
| **Subsample** (Students with the same teachers as AIAN Students) | | | | | |
| *Student Report* | | | | | |
| Standards-Based Classroom Activities[f] | 2.24 | 2.21 | 2.47 | 2.23 | 8.44* |
| Sample Size | 213 | 962 | 292 | 266 | |

* p<.001
[a] American Indian/Alaska Native students
[b] Mean of 3 items coded as 1=little/no knowledge, 2=somewhat knowledgeable, 3=knowledgeable, and 4=very knowledgeable.
White, African American, Latino > AIAN
[c] Number of professional development activities attended, ranging from 0 to 3.
White, Latino > African American, AIAN
[d] Mean of 7 items coded as 1=never or hardly ever, 2=once or twice a year, 3=once or twice a month, and 4=once or twice a week.
African American >Latino > White, AIAN
[e] Mean of 4 items coded as 1=never or hardly ever, 2=1–2 times a month, 3=1–2 times a week, and 4=almost everyday.
African American > Latino > AIAN, White
[f] African American > Latino, AIAN, White

The data show that the same pattern exists between student report of standards-based classroom activities and teacher report of standards-based instruction. African American students were most likely to report that they worked on standards-based activities in classroom (e.g. solve mathematics problems with a partner or in small groups, write about solving a math problem), followed by Latino students. White students and AIAN students were significantly less likely than African American and Latino students to report that they participated in standards-based classroom activities. While White students reported the lowest level of standards-based classroom activities, there was no statistically significant difference between White students and AIAN students—the same result as the teacher-reported standards-based instruction.

When we interpret student report of standards-based classroom activities, it is important to know whether there is a variation in the student perception of the same classroom activities. In another words, we need to know whether students of different ethnic groups interpret the same classroom activities provided by the same teachers differently. In order to test the possible

differences in student interpretation of the same classroom activities, we selected only the students who were taught by the same teachers in the same schools, and compared their reports of classroom activities. If students perceive standards-based classroom activities in the same way, there should be no statistically significant differences among four ethnic groups in their reports of classroom activities provided by the same teachers.

The lower part of Table 2 under "Subsample" presents the results. There was no statistically significant difference in their reports among AIAN students, White students, and Latino students. However, African American students reported a significantly higher level of standards-based classroom activities than the other three groups. This result shows that student interpretation of standards-based instruction is not consistent across different ethnic groups, and that African American students tend to report the classroom activities more positively than other students. If their interpretation of instruction is what shapes student achievement, rather than teacher instruction, this result points to the importance of paying attention to student interpretation of classroom activities. Our final analysis examined how teacher-reported standards-based knowledge, professional development, and instruction, and student-reported standards-based classroom activities are associated with student achievement among AIAN students, White students, African American students, and Latino students.

**Standards-Based Reform Factors and Mathematics Achievement of American Indian/Alaska Native students in Comparison to Other Students**

In this analysis, we chose the subsamples of White, African American, and Latino students who have the same teachers in the same schools as AIAN students as comparison groups rather than national sample of these groups. This allows us to control for the differences in teacher and school characteristics across ethnic groups that were not measured in the NAEP dataset. We further randomly selected 171 students from each group of comparison to make the sample size consistent with that of AIAN students. This procedure can ensure that the significance level of standards-based reform factors is not affected by different sample sizes.

We first examined bivariate relationships among four standards-based reform variables separately for each ethnic group using Pearson's correlations (sample size = 171). Across all four ethnic groups, there were positive relationships among teacher-reported standards-based knowledge, standards-based professional development, and standards-based instruction, and most of them were statistically significant. The strongest relationship was between standards-based knowledge and standards-based professional development (.40 for AIAN, .33 for White, .40 for African American, and .56 for Latino students, all statistically significant). The teachers who participated in standards-based professional developments are more likely to report that they are knowledgeable about standards and that they practice standards-based instruction.

Teacher-reported standards-based instruction and student-reported standards-based instruction were also significantly and positively associated with each other for all ethnic groups, although the sizes of the Pearson correlation coefficients were small (.20 for AIAN, .15 for White, .19 for African American, and .23 for Latino students; $N$ = 171). However, the relationship between standards-based knowledge or standards-based professional development and student-reported standards-based instruction differed across the ethnic groups. For White, African American, and Latino students, there was no statistically significant relationship. On the contrary, among AIAN students, teacher report of participation in standards-based professional development was significantly and negatively associated with student report of standards-based classroom activities. AIAN students who were taught by mathematics teachers who participated in standards-based

professional development were less likely to report that they experience standards-based classroom activities.

Because of the high correlation between standards-based knowledge and standards-based professional development, we decided to enter each of four standards-based reform variables separately in four models. Table 3 presents the results of multiple regression analyses on the relationship between standards-based knowledge, standards-based professional development and student achievement, and Table 4 presents the relationship between teacher-reported standards-based instruction, student-reported standards-based classroom activities, and student achievement. All the models include seven control variables: student gender, parents' education level, years of mathematics teaching experience, mathematics major of the teacher, mathematics education major of the teacher, school size, and school poverty level.

Table 3 shows that the relationship between teacher-reported standards-based knowledge and student mathematics achievement is not significant for any of the four ethnic groups. The effect sizes of the relationship were 0.23 for AIAN, 0.18 for White, 0.01 for African American, and 0.09 for Latino students.[9] While there is a moderate effect size for AIAN and White students, none of the regression coefficients were statistically significant. This indicates that the achievement level of students taught by teachers who reported that they are knowledgeable about standards was no different from the achievement level of students taught by teachers who reported that they know little about standards. The relationship between the teacher report of participation in standards-based professional development activities and student mathematics achievement was not consistent across four ethnic groups. For AIAN students, there was a statistically significant, negative relationship between these factors, in contrast to a non-significant relationship for White, African American, and Latino students. The effect sizes of the relationship were -0.62 for AIAN, -0.11 for White, 0.01 for African American, and 0.12 for Latino students. AIAN students who were taught by teachers who participated in standards-based professional development activities achieved lower than other AIAN students who were taught by teachers who did not participate in the professional development activities.

What explains this negative relationship? Our previous analysis showed that teacher report of professional development activities was significantly and negatively associated with student report of standards-based classroom activities. It may be that those teachers who struggle with how to implement standards-based classroom activities were more likely to participate in such professional development activities either voluntarily or by requirements from the school or district administrators.

Table 4 presents the relationship between teacher-reported standards-based instruction, student-reported standards-based classroom activities, and student mathematics achievement, controlling for the same set of student, teacher, and school background characteristics. None of the teacher-reported standards-based instruction was significantly associated with mathematics achievement of the four groups. The effect sizes for the relationship were 0.12 for AIAN, 0.05 for White, -0.23 for African American, and 0.20 for Latino students. The students taught by teachers who reported that they practice standards-based instruction did not achieve significantly higher than the other students whose teachers reported that they do not practice standards-based instruction.

[9] The standardized coefficients in multiple regression were converted to effect sizes using Friedman's (1968, p. 246) formula #6: $d = [2 (r)] / [(1 - r^2)^{.5}]$.

Table 3
*Relationship between Standards-Based Knowledge, Professional Development, and Mathematics Achievement* [a]

| | **Standards-Based Knowledge** | | | | **Standards-Based Professional Development** | | | |
|---|---|---|---|---|---|---|---|---|
| Variable | AIAN[b] *B* (*SE*) | White *B* (*SE*) | African American *B* (*SE*) | Latino *B* (*SE*) | AIAN[b] *B* (*SE*) | White *B* (*SE*) | African American *B* (*SE*) | Latino *B* (*SE*) |
| *Student Characteristics* | | | | | | | | |
| Gender [c] | -.13 (5.29) | -4.35 (6.76) | 1.41 (6.71) | -2.64 (7.03) | .70 (4.94) | -5.12 (6.61) | 1.42 (6.71) | -2.88 (7.23) |
| Parents' Education | 6.27 (2.65)* | 4.99 (4.75) | 6.37 (3.62) | 2.76 (2.76) | 5.43 (2.56)* | 4.34 (4.99) | 6.35 (3.56) | 3.02 (2.84) |
| *Teacher Characteristics* | | | | | | | | |
| Experience | 9.36 (9.46) | 8.73 (10.72) | 4.42 (18.27) | 5.03 (6.70) | 11.53 (7.77) | 10.13 (11.14) | 4.36 (14.58) | 4.86 (6.93) |
| Math Major | -14.39 (7.91) | -1.95 (7.98) | -17.28 (6.74)** | -3.09 (8.05) | -8.14 (6.36) | -1.54 (7.69) | -17.13 (7.74)* | -2.09 (7.83) |
| Math Ed Major | .17 (7.66) | -.98 (7.45) | -5.28 (11.34) | 18.37 (10.58) | 7.17 (5.02) | .92 (6.69) | -5.39 (10.61) | 18.35 (9.70) |
| *School Characteristics* | | | | | | | | |
| School Size (100s) | -.10 (.20) | -1.00 (1.00) | -1.50 (1.20) | .00 (.20) | -.10 (.20) | -1.00 (1.00) | -1.60 (1.40) | .00 (.20) |
| Poverty Level[d] | -4.33 (1.52)** | -1.29 (2.64) | -4.02 (2.03)* | -4.39 (1.82)* | -5.03 (1.25)*** | -1.43 (2.75) | -3.99 (1.99)* | -4.47 (1.61)** |
| *Standards-Based Reform Factors* | | | | | | | | |
| Knowledge | 3.79 (3.58) | 3.71 (6.84) | .12 (9.37) | 1.67 (4.24) | | | | |
| Prof. Development | | | | | -11.32 (5.09)* | -1.72 (4.47) | .25 (5.62) | 2.53 (4.23) |
| $R^2$ | .14 | .09 | .23 | .13 | .21 | .09 | .23 | .14 |
| *N* | 171 | 171 | 171 | 171 | 171 | 171 | 171 | 171 |

* p<.05, ** p<.01, *** p<.001
Notes: [a] The dependent variable is the five plausible values of mathematics score.
[b] American Indian/Alaska Native students
[c] Coded as male = 1 and female = 0
[d] Percentage of students receiving free or reduced lunch coded as 1 = 0%, 2 = 1–5%, 3 = 6–10%, 4 = 11–25%, 5 = 26–50%, 6 = 51–75%, 7 = 76–99%, 8 = 100%.

Table 4
*Relationship between Standards-Based Instruction and Mathematics Achievement*[a]

| | **Standards-Based Instruction (Teacher Report)** | | | | **Standards-Based Classroom Activities (Student Report)** | | | |
|---|---|---|---|---|---|---|---|---|
| Variable | AIAN[b] *B* (*SE*) | White *B* (*SE*) | African American *B* (*SE*) | Latino *B* (*SE*) | AIAN[b] *B* (*SE*) | White *B* (*SE*) | African American *B* (*SE*) | Latino *B* (*SE*) |
| *Student Characteristics* | | | | | | | | |
| Gender [c] | .08(5.06) | -5.01(6.57) | 2.17(6.53) | -2.46(7.12) | 3.66(5.24) | -5.12(6.53) | 2.09(6.87) | -1.91(7.31) |
| Parents' Education | 5.96(2.61)* | 4.59(4.96) | 6.01(3.67) | 3.02(2.72) | 5.76(2.69)* | 4.49(4.98) | 5.61(3.44) | 2.88(2.81) |
| *Teacher Characteristics* | | | | | | | | |
| Experience | 10.73(9.14) | 10.13(11.02) | 8.59(15.68) | 5.76(6.97) | 8.75(8.60) | 9.95(11.10) | 4.31(15.04) | 6.01(6.17) |
| Math Major | -12.90(8.34) | -.55(7.49) | -18.63(6.83)** | -3.73(7.88) | -14.18(6.88)* | -.66(7.57) | -15.34(6.80) * | -2.23(7.85) |
| Math Ed Major | 2.22(6.65) | .40(7.09) | -5.93(10.26) | 19.83(10.27) | 1.63(5.55) | -.10(7.34) | -5.75(10.50) | 20.84(10.07)* |
| *School Characteristics* | | | | | | | | |
| School Size (100s) | -.10(.20) | -.90(1.00) | -1.60 (1.20) | .00(.20) | -.10(.20) | -.90(1.00) | -1.70(1.30) | .00(.20) |
| Poverty Level[d] | -4.85(1.25)*** | -1.51(2.92) | -4.15(1.89)* | -4.49(1.75)** | -4.75(1.20)*** | -1.41(2.96) | -3.98(1.95) * | -4.63(1.69)** |
| *Standards-Based Reform Factors* | | | | | | | | |
| Instruction (T report) | 4.00(7.00) | 1.27(6.73) | -7.52(6.41) | 7.52(8.05) | | | | |
| Class Activities (Student report) | | | | | 11.36(5.19)* | -1.13(5.09) | -5.40(4.08) | -5.92(4.00) |
| $R^2$ | .14 | .08 | .24 | .14 | .21 | .08 | .24 | .15 |
| *N* | 171 | 171 | 171 | 171 | 171 | 171 | 171 | 171 |

* p<.05, ** p<.01, *** p<.001
Notes: [a] The dependent variable is the five plausible values of mathematics score.
[b] American Indian/Alaska Native students
[c] Coded as male = 1 and female = 0
[d] Percentage of students receiving free or reduced lunch coded as 1 = 0%, 2 = 1–5%, 3 = 6–10%, 4 = 11–25%, 5 = 26–50%, 6 = 51–75%, 7 = 76–99%, 8 = 100%.

How is student report of standards-based classroom activities associated with student achievement? We found that among AIAN students, student report of standards-based instruction was significantly and positively associated with mathematics achievement. However, this relationship was not statistically significant for White, African American, and Latino students. The effect sizes for the relationship were as large as 0.60 for AIAN, compared to -0.05 for White, -0.23 for African American, and -0.27 for Latino students.

AIAN students who reported that they solved math problems with a partner or in small groups, used measuring instruments or geometric solids, wrote about solving a math problem, and talked with other students during class about how they solved mathematics problems achieved significantly higher in mathematics than the other AIAN students who did not experience these activities in their classrooms. This finding may indicate that, for AIAN students, their perception of standards-based classroom activities they experienced matters more for their learning than the teacher report of standards-based instruction provided to them.

Why was there no significant relationship between student report of standards-based classroom activities and student achievement for White, African American, and Latino students who are taught by the same teachers as AIAN students? A possible explanation may be that AIAN students have identified the similarity between the constructivist approach in the standards-based classroom activities and Native American pedagogy as the literature suggests (Hankes, 1998; Hankes & Fast, 2000). Compared to AIAN students, White, African American, and Latino students who go to the same schools may not have perceived the activities as culturally relevant. The standards-based classroom activities students experienced in these schools may have had unique culturally-relevant characteristics that benefited learning of AIAN students, but not the learning of other students.

## Discussion

This study examined the relationship between standards-based teacher knowledge, professional development, and instructional practice, and mathematics achievement of AIAN eighth-graders using nationally representative data from the NAEP 2000 mathematics dataset. We found that AIAN students were least likely to be taught by mathematics teachers who reported that they were knowledgeable about the NCTM, state, and local mathematics standards and who participated in standards-based professional development activities. Their opportunity to be taught by teachers who reported that they practice standards-based instruction was also among the lowest.

Our data also showed that only 27% of AIAN students were in mathematics classes with teachers who majored in mathematics, and only 21% of them were in classes with teachers who majored in mathematics education. The 2005 nationally-representative data reported by the National Indian Education Study (Stancavage et al., 2006) found that 36% of eighth-grade AIAN students were taught mathematics by teachers whose undergraduate major is in mathematics-related areas, compared to 45% among other students. While a larger percentage of AIAN students was taught by teachers with mathematics-related majors in 2005 than 2000, this percentage was still the smallest of the studied ethnic groups.

All of these data seem to indicate that AIAN students have fewer opportunities to be taught mathematics by teachers with sufficient subject content knowledge and pedagogical knowledge and skills on student-centered, constructivist instruction than White, African American, and Latino students. This opportunity gap—who is taught by qualified teachers with standards-based knowledge, learning opportunities, and practice along the lines of ethnicity and socioeconomic status—is a serious problem that needs to be systematically addressed (Darling-Hammond, 2006). Indeed, the level of opportunity gap between high-SES and low-SES students in who has qualified

teachers in the U.S. was among the largest in a comparative study of opportunity gap in 47 countries (Akiba, LeTendre, & Scribner, 2007).

If the teachers of AIAN students fully understand the importance of connecting the mathematics content with their students' daily experiences and culture, and deliver instruction that is relevant to AIAN students, as promoted by standards-based mathematics reforms, we should see that standards-based teacher knowledge, professional development, and practice are significantly associated with higher mathematics achievement. However, our analysis did not support the expected positive relationships between these factors. AIAN students taught by teachers who reported that they were knowledgeable about NCTM, state, and local standards did not achieve higher than the other AIAN students whose teachers reported little knowledge. This result indicates that being knowledgeable about the standards does not guarantee that teachers know how to effectively teach mathematics by connecting mathematics content with AIAN students' daily experiences.

Our data also did not support the expected positive relationship between standards-based professional development and mathematics achievement among AIAN students. Indeed, we found a significant, negative relationship between these factors. AIAN students taught by mathematics teachers who reported that they studied problem solving, use of manipulatives, and student mathematics thinking achieved lower than other AIAN students taught by teachers who did not participate in standards-based professional development activities. The teachers of low-achieving students may be more likely to participate in such activities than the teachers of high-achieving students. Our data also showed that the teachers whose students reported lower level of standards-based classroom activities were most likely to participate in standards-based professional development.

Another explanation is that the standards-based professional development activities do not specifically address how to practice constructivist instruction in the context of culturally-diverse classroom environments. According to the National Indian Education Study (Stancavage et al., 2006, p.47), mathematics teachers of AIAN eighth-graders reported that "living and working in the community" as the most common method to acquire knowledge and skills specific to teaching AIAN students, followed by "personal or family background and experience" and "independent reading and study." "Classes and workshops that were not taken as part of a degree program" was fourth common method to acquire knowledge and skills for teaching AIAN students, followed by "college courses taken as part of an undergraduate or graduate degree program." These data show that mathematics teachers of AIAN students may not perceive standards-based professional development offered through college or university courses or in professional development workshops or seminars as relevant or important for learning how to teach AIAN students. If the standards-based professional development activities the teachers participated did not focus on the importance of integrating American Indian/Alaska Native culture into their teaching, as our data showed, it could have a negative impact on student achievement.

Teacher report of standards-based instruction was not significantly associated with mathematics achievement of AIAN students. However, student report of standards-based classroom activities was significantly and positively associated with the achievement of AIAN students. The AIAN students who reported that they frequently work on standards-based classroom activities, solving math problems with partner or in group, using measuring instruments or geometric solids, writing about solving a math problem, and talking with class about solved math problems, were more likely to achieve highly than the other AIAN students who did not work on standards-based classroom activities with an effect size of 0.60.

Constructivist theory explains that teachers' effort to understand students' daily experiences and connect them with school mathematics is crucial. Teachers need to have a good understanding

of cultural experiences including cultural objects, values, and language of AIAN students in order to connect their day-to-day experiences and understanding of mathematics at home with new mathematical concepts to be taught in classroom (Hankes, 1998; Hankes & Fast, 2002). Mathematics activities are positively perceived and remembered when AIAN students see that their mathematics teachers successfully made a connection between their daily experiences and classroom activities. Therefore, students are more likely to report that they experienced standard-based classroom activities when this alignment between cultural experiences and values and mathematics activities occurred in their classrooms.

This is the aspect that teacher report of standards-based instruction is unable to measure. What the teacher perceived he or she delivered in the classroom is not necessarily the same as what students perceived having received. The fact that the student report of standards-based classroom activities was significantly associated with mathematics achievement of AIAN students only, and not with mathematics achievement of White, African American students, and Latino students, indicates the possibility of unique nature of classroom activities that benefited AIAN students.

The National Indian Education Study reported that 30% of AIAN eighth-graders are taught by mathematics teachers who use mathematics problems that reflect situations typical of American Indian/Alaska Native homes (Stancavage et al., 2006, p.53). The percentage rises to 45% in the schools where at least 25% of students are American Indian/Alaska Native. In addition, 10% of AIAN eighth-graders' teachers use American Indian/Alaska Native perspective extensively in mathematics instruction, and 23% go to a school whose principal reported using American Indian/Alaska Native perspective in the school curriculum extensively (Stancavage et al., 2006). These percentages rise to 17% and 34% in the schools where at least 25% of students are American Indian/Alaska Native. Furthermore, 56% of AIAN students go to schools where tribal or Alaska Native community representatives participated in school activities to share native traditions and culture (Stancavage et al., 2006), and 38% go to schools where instruction in students' American Indian/Alaska Native language(s) is available (Stancavage et al., 2006, p.37). In the schools where at least 25% of students are AIAN students, the percentages are 75% and 62%, respectively.

In our sample, 31% of AIAN students go to schools where at least 25% of students are American Indian or Alaska Native. These statistics from the National Indian Education Study show that the AIAN students in our sample are likely to be exposed to mathematics instruction and problems relevant to their culture in a school environment where native language and culture are emphasized. It is likely that the standards-based classroom activities in mathematics reported by AIAN students integrated American Indian/Alaska Native perspective with their daily experiences at home. This may explain why student report of standards-based classroom activities are significantly associated with mathematics achievement of AIAN students, but not of other students.

Our data showed that the importance of student experience of standards-based classroom activities in predicting mathematics achievement of AIAN students. Compared to other teacher-reported measures of standards-based knowledge, professional development, and instruction, this measure reflects most precisely what students experienced in mathematics classrooms from student perspectives. Students are more likely to remember and report classroom activities that have relevance to their daily experiences and culture. While the NAEP data do not have any measures on cultural relevance in standards-based teacher knowledge, professional development, and instruction, the evidence from the National Indian Education Study seems to support that the AIAN students in our sample have experienced classroom activities that are relevant to their culture and daily experiences. Our finding supports the importance of paying attention to student experiences and perceptions of classroom activities to understand what conditions are most effective in facilitating student learning.

While this study supported the philosophy of constructivist theory underlying standards-based instruction, it is important to point out that constructivist theory does not address how social context and power relationships in school settings impact students' learning experience. Sociocultural theory explains that schools have a mainstream White culture, which does not support the learning styles or teaching methods used by Native American parents or caregivers. Therefore, when AIAN students come to school, not only do they need to learn new content, but they also must become participants in a new cultural context (Deyhle, 1995; Lipka, 1994; Pewewardy, 2002). According to this perspective, the cultural differences in communication styles, behaviors, and values between AIAN students and the Anglo school's culture lead to conflicts and misunderstanding between the two and, ultimately, the failure of AIAN students (Deyhle, 1995; Jeffries & Singer, 2003; Pewewardy, 2002; Powers, Potthoff, Bearinger, & Resnick, 2003).

Critical theory focuses on the larger political, social, and economic contexts that produce the power relationship between racial/ethnic groups. The theory emphasizes the power struggle between Anglos and Native Americans over the education of AIAN students at Anglo-controlled schools that assimilate them into Anglo American society. While allowing Native American languages and cultures in schools, the theory posits that the government has controlled the aspect of Native American life that is radically different and considered dangerous to the nation-state (Lomawaima & McCarty, 2002; Noel, 2002). School curriculum—including standards, textbooks, and assessments in public schools, which are dominated by mainstream cultures and values—works as a filter to socially stratify students. Critical theorists argue that understanding and critically questioning the inequality in a school as a result of power structure in our society is the first step for educators to provide improved educational experiences for minority students (Apple, 1993, 1995).

These theoretical perspectives explain that student-centered instruction will not be effective unless teachers understand the culturally-biased nature of school curriculum and their own teaching, and actively seek to understand the values and cultures of American Indian/Alaska Native communities (Apple, 1995; Brenner, 1998; Deyhle & Swisher, 1997; Swisher & Deyhle, 1987). Moreover, special efforts are needed to alter the classroom culture shared by teachers and students, which suffered AIAN students through teachers' low expectations and biased cultural images imposed on them (Dumont, 1972; Noel, 2002).

Mathematics teachers of AIAN students may face challenges in their efforts to acquire knowledge and skills of teaching in a culturally-congruent way if their peer teachers do not support their efforts, or if the school does not see their efforts as aligned with other school priorities. These theoretical perspectives point to the importance of critically assessing the nature of curriculum, instruction, and classroom activities from multicultural perspectives. Student learning is shaped not only by classroom activities but also by the curriculum and instructional materials, and by the broader school environment. The level of affirmation and support of student culture reflected in school curriculum, instructional materials, and student-teacher interaction and peer interaction at school influences how effectively students learn. Teachers of AIAN students need to assess these broader organizational and social factors surrounding their students and act if necessary as social agents to make students' learning environment culturally-relevant.

**Methodological Implications**

This study was unique in its examination of student-reported standards-based classroom activities in comparison to teacher-reported constructivist instruction. The weak relationship between student report and teacher report (Pearson R = .20 for AIAN, .15 for White, .19 for African American, and .23 for Latino students) shows that teacher perception of instructional

delivery is not closely aligned with student experience and perception of mathematics activities in classrooms. The impact of standards-based instruction on student learning is mediated by students' perceptions and experiences of classroom activities. Therefore, the intended purpose of standards-based instruction will not be achieved unless students actually see the connection between their culturally-embedded daily experiences and classroom activities and are engaged in communicating their mathematical thinking with classmates to achieve a deeper mathematical understanding.

Our data support that this process is important for AIAN students (as well as other ethnic minority students) who will not see the connection between their daily experiences and classroom activities unless mathematics teachers are aware of cultural experiences of these students at home and actively integrate them into the lessons. If achievement gaps are to be narrowed, then, identifying effective instructional practices that support ethnic minority students' learning should be a major policy agenda. In large-scale survey research where observation of instructional practices by researchers is not possible, it is important for researchers to continuously improve the quality of survey measures. One promising direction in measurement development is focusing on student-reported measures, on instructional practices, and on measuring the extent to which the classroom activities are relevant to students' culturally-embedded daily experiences.

Survey measures on teacher knowledge are also important factors that predict instructional practices and student achievement (Cohen & Hill, 2000; Hill, Rowan, & Ball, 2005). While teacher knowledge of mathematics standards guided by constructivist theory is important, having this knowledge alone is not sufficient for practicing standards-based instruction. Teachers need to have deep content knowledge (Grossman, 1990; Shulman, 1986; 1987) as well as knowledge necessary for teaching mathematics to students, including knowledge of students' mathematical understanding (Ball, 1991; Borko et al., 1992; Hill et al., 2005; Hill, Schilling, & Ball, 2004).

In addition, teacher knowledge of students' mathematical understanding from cultural perspectives is important in order for mathematics teachers to make connection between student experiences and new mathematical concepts (Cahnmann & Remillard, 2002). Few studies measured this aspect thus far. Yet, it is an important area of teacher knowledge that needs to be measured through survey methods in order to identify effective instructional practices for culturally-diverse students.

Survey measures on professional development in large-scale survey research need to focus on diverse aspects of activities that shape the learning experiences of teachers so that we can identify and produce useful information on what specific features of professional development are effective in promoting teacher learning and eventually, student learning. Professional development that prepares teachers to effectively teach culturally-diverse students is a topic few studies have investigated using survey methods (Zeichner & Hoeft, 1996). With the limited nature of multicultural teacher education for pre-service teachers characterized by single courses within teacher education programs with peripheral status (Cochran-Smith, Davis, & Fries, 2004; Gay, 2002; Ladson-Billings, 1995; 1999; Zeichner & Hoeft, 1996), it is important that we understand the nature of teachers' opportunity to learn how to teach culturally-diverse students after graduating from teacher education programs.

Mathematics teachers of AIAN students do not rely on standards-based professional development offered through college or university courses or in professional development workshops or seminars to acquire knowledge and skills for teaching AIAN students (Stancavage et al., 2006). It is important to measure the nature of teacher learning of effective teaching through other venues such as working with the community members. It is crucial that mathematics teachers understand Native pedagogy and develop instruction that is relevant to daily experiences of AIAN students. The tribal communities would be the best resources for mathematics teachers to acquire knowledge and skills for effectively teaching AIAN students.

**Policy Implications**

We began this study with the question of whether standards-based mathematics reforms benefit American Indian/Alaska Native students' learning. The results of the research reported in this article show that it depends on how standards-based classroom activities are perceived and experienced by American Indian/Alaska Native students. Our data shows that AIAN students who reported that they experienced standards-based classroom activities achieved at a higher level than the students who did not experience such activities. Teacher reports of standards-based instruction did not predict student achievement, a finding that what matters is students' perceptions and experiences of classroom activities, not what teacher perceive they taught in the classroom.

This finding supports that researchers, educators, and policymakers need to pay attention to student experiences of standards-based classroom activities. For standards-based classroom activities to be positively perceived and experienced by students, mathematics teachers need to first understand their students' prior mathematics-related knowledge in daily experiences. Students' mathematics-related knowledge in outside-school environments is embedded in the daily experiences shaped by their cultures, and teachers serving ethnically-diverse classrooms need to understand how to connect mathematics content to various cultures represented by their students.

The success of standards-based student learning depends on teachers' learning opportunities to connect mathematics content and students' outside-school experiences. Because only 16% of full-time K-12 public school teachers are ethnic minorities (U.S. Department of Education, 2003a) and they are serving an increasingly diverse student population with ethnic minority students constituting 43% in 2004 (U.S. Department of Education, 2006), their opportunities to learn cultures different from their own is crucial. Mathematics teachers of AIAN students often rely on working with the tribal communities to acquire the knowledge and skills for teaching their students. Our data showed that AIAN students were least likely to be taught by mathematics teachers who reported that they were knowledgeable of standards, participated in standards-based professional development, and practiced standards-based instruction. It is important that professional development opportunities provided to teachers of AIAN students integrate how to put the ideas of constructivist instruction into practice in the context of American Indian/Alaska Native cultures.

Collaboration between the providers of professional development activities and tribal communities would facilitate a development of teacher learning opportunities on how to effectively teach AIAN students. This applies to the teachers teaching other ethnic minority students as well. Mathematics teachers need to be provided with ample opportunities to understand culturally-embedded daily experiences of ethnicity minority students as well as of White students, and learn how to develop classroom activities reflective of the various cultural experiences of their students.

While the No Child Left Behind Act of 2001 promotes standards-based reforms, it is important to examine the impact of an accountability system on teacher practice of constructivist instruction. If the accountability system shifts the focus from connecting mathematics content to students' culturally-embedded daily experiences to teaching students test-taking skills to do well in standardized exams, students' learning experiences will not be improved and the achievement gap will persist. The achievement gap in the United States has not narrowed for many years (Harris & Herrington, 2006). A gap in teacher qualification such as certification, subject major, and teaching experience between teachers in wealthy, white-dominant schools and high-poverty, ethnically-diverse schools is among the largest in the world (Akiba, LeTendre, & Scribner, 2007). To narrow the learning opportunity gap between White students and ethnic minority students, we need to carefully examine students' experiences of classroom activities and how their experiences promote learning. Teachers' opportunities to learn ethnic minority students' cultures and how to develop

culturally-relevant instruction is the critical first step for improving learning opportunity of all students, and narrowing the long-lasting achievement gap.

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