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Comparing Teachers' Conceptions of Mathematics Education and Student Diversity at Highly Effective and Typical Elementary Schools

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In this study, the authors examined what distinguished highly effective from typical elementary schools in mathematics by examining the conceptions of fourth-grade teachers with regards to mathematics education (curriculum, instruction, and assessment) and student diversity (ability, culture, language, and socioeconomic status). The study was conducted in two large urban areas with high proportions of racially/ethnically and linguistically diverse student groups. Interviews were conducted with 32 fourth-grade teachers from 16 elementary schools, including 10 highly effective and 6 typical schools in the two areas. Compelling evidence was found that teachers at highly effective schools had better developed and better articulated conceptions of mathematics education and student diversity. While similar findings were found across the two areas (e.g., teachers' beliefs about the influence of high-stakes assessment and the academic ability of low-achieving students), differences were also found across the two areas (e.g., teachers' beliefs about the importance of implementing multiple instructional strategies and expectations for college attendance).

KEYWORDS: conceptions of mathematics, highly effective schools, student diversity, urban schools

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The purpose of this study was to examine what distinguishes highly effective from typical elementary schools in mathematics achievement by examining the conceptions (knowledge and beliefs) of fourth-grade teachers. Specifically, we compared teachers at highly effective schools with teachers at typical schools with regards to their conceptions in mathematics education (curriculum, instruction, and assessment) and student diversity (ability, culture, language, and socioeconomic status).

It is clear from research that teachers' conceptions of mathematics content, instruction, and assessment are strongly linked to classroom practice and student learning in interesting and complex ways. What remains under researched in the literature on teachers' conceptions and practices is the role of race/ethnicity, culture, and language in mathematics education (Rodriguez & Kitchen, 2005; Rousseau & Tate, 2003). In this study, we pursued an integrated research project that examined the influence of teachers' conceptions with regards to *both* mathematics education and student diversity on student learning and achievement. Two specific research questions guided the study:

1. How do teachers at highly effective schools articulate their conceptions of mathematics education compared to their colleagues at typical schools?

2. How do teachers at highly effective schools articulate their conceptions regarding student diversity compared to their colleagues at typical schools?

Another distinguishing feature of this study is that we searched for characteristics that differentiated schools rather than classrooms. This perspective necessitates that we consult the effective schools literature. Much of this research identifies factors other than instruction as distinguishing more from less effective schools (Edmonds, 1979; Good & Brophy, 1986; Martin, Mullis, Gregory, Hoyle, & Shen, 2000; Purkey & Smith, 1983). These factors include school-level characteristics such as principal leadership, orderliness and safety, or opportunities at home such as access to reading materials. Interestingly, the Third International Mathematics and Science Study (TIMSS) results indicate that although the nature of mathematics and science instruction was important, it was not a defining characteristic distinguishing high from low performing schools (Martin, et al., 2000).

In light of increasing pressure being placed on schools to enhance student learning and achievement in mathematics, there is a danger that policymakers view the effective schools literature as suggesting that instructional quality fails to distinguish more from less effective schools. We sought to contest this potential pitfall by providing empirical evidence to address the gap in the research literature on the link between school-level effectiveness and student learning and achievement. To accomplish this goal, we investigated teachers' conceptions of and explanations for their practices in mathematics with diverse student groups.

Conceptual Framework

We examined the conceptions of teachers from multiple school districts across two of the USA's major metropolitan areas. Teachers' responses were examined through a complex lens that includes constructs related to school organization, mathematics education, and multicultural education. The corresponding areas of literature that provided the conceptual framework for this study are: (a) school restructuring, (b) teachers' conceptions in mathematics education, and (c) teachers' conceptions in addressing student diversity.

School Restructuring

In research on school restructuring and its relationship to student performance on high-level tasks, Newmann and Associates (1996; Newmann, Secada, & Wehlage, 1995; Newmann & Wehlage, 1995) found that students enrolled in schools where the curriculum content and instruction focused on depth over coverage, analytic reasoning over memorization, and the construction of value over doing tasks as ends in themselves out performed students whose classrooms lacked these instructional features. Lee and Smith's (2001) study of secondary schools supports Newmann et al.'s findings. At secondary schools where mathematics and science course offerings were predominantly academic and where teachers as a whole tended to report instruction that focused on depth and higher order thinking, students evidenced higher achievement in mathematics and science and began to close the achievement gap based on social class, compared to schools where these instructional characteristics were lacking.

In this study, we sought to examine whether teachers in highly effective schools were more likely than their counterparts at typical schools to articulate their goals to implement mathematics curricula and instruction as reported in Newmann and Associates (1996) and Lee and Smith (2001).

Teachers' Conceptions in Mathematics Education

In the past several decades, notions about teachers' conceptions (knowledge and beliefs) of mathematics content (Ma, 1999), instruction (Ball & Cohen, 1999), and assessment (Kulm, 1994) have dramatically changed. Current reforms in mathematics education stress the need for problem-solving approaches to promote students' reasoning and communication skills (National Council of Teachers of Mathematics [NCTM], 1989, 2000; National Science Foundation [NSF], 1996). Furthermore, the mathematical processes of making connections, communicating, representing, and problem solving are no longer viewed as ends in themselves but as means to learning mathematics with understanding (Hiebert & Carpenter, 1992; Hiebert, et al.1996). The incongruity between this vision and the conceptions of many practicing mathematics teachers (e.g., mathematics as a sequential, rule-based discipline in which memorizing facts and following procedures are highly valued) has been well documented (e.g., Romberg, 1992). Three perspectives on teachers' conceptions of mathematics education are described next.

Ernest (1988, 1991) identified three possible views of the nature of an academic discipline. The first, called instrumentalist, views a discipline as an isolated body of discrete skills. The second, called Platonist, regards a discipline as a body of connected and unified knowledge. The third, called problem-solving, deems a discipline as a process of inquiry that is continuously expanded by human creation. These three distinctions have also been cast as a duality between absolute (e.g., instrumentalist) and fallible (e.g., problem-solving) views that take shape in beliefs about mathematical knowledge and legitimate mathematical activities (Romberg, 1992; Thompson, 1992).

Teachers who embrace an instrumentalist view often look at mathematics as a sequence of fixed skills or concepts. Mastery of pre-requisite skills is deemed necessary for subsequent learning. This view assumes that "rules are the basic building blocks of all mathematical knowledge and all mathematical behavior is rule governed" (Thompson, 1992, p. 136). Thompson (1992) argued that there is a consistent relationship between teachers' beliefs and instructional practices in mathematics. Because mathematics is characterized as static and predetermined in the instrumentalist philosophy, those who adhere to this view emphasize mathematical facts and pursue the drill-and-practice approach to teaching (Schifter & Fosnot, 1993).

In contrast, teachers who adhere to a Platonist view of mathematics emphasize the logic that connects concepts. These relationships are assumed to be fixed and often require explanations by the teacher. This view models a top-down approach in which instruction begins with the knowledge of the expert, rather than that of the learner (Hiebert & Carpenter, 1992). An example of teachers who embrace the Platonist view of mathematics is provided in Liping Ma's book, *Knowing and Teaching Elementary Mathematics* (1999). A theme that runs throughout Ma's book is that teachers must possess a deep and broad knowledge of mathematics to make conceptual connections between mathematical ideas.

On the other hand, teachers who adopt a problem-solving or inquiry view of mathematics see their role as posing questions and challenging students to think and reason. Teachers whose primary objective is to advance mathematical problem solving advocate that students are the ones "doing mathematics" (Davis & Hersh, 1980; Ernest, 1991; Lakatos, 1976; Tymoczko, 1986). From this view, "learning is primarily a process of concept construction and active interpretation—as opposed to the absorption and accumulation of received items of information" (Schifter & Fosnot, p. 8, 1993). Pedagogy inspired by this view engages students in posing and solving problems, making and proving conjectures, exploring puzzles, sharing and debating ideas, and contemplating the beauty of ideas in an academic discipline.

Alternative or multiple assessment formats that do not simply assess facts and skills in isolation, but that also require students to apply their knowledge in real-life contexts align more with the Platonist or problem-solving view. According to Kulm (1994):

> Alternative assessment approaches that include open-ended questions, presentation of solutions in both written and oral form, and other performances send very different messages to students about what is important in mathematics learning….The shift from an emphasis on producing correct answers to the expectation that students think and communicate is a major one for many students and teachers. (p. 6)

This shift of emphasis corresponds to the philosophical change necessary for an instrumentalist to become a Platonist or to promote problem-solving. Such a shift is supported by researchers who advocate revising assessment practices to bring about changes in instruction based on how children learn (O'Day & Smith, 1993). In addition, alternative assessment approaches and the use of multiple assessment formats require students to communicate their thinking and elicit a range of student responses (Wiggins & McTighe, 1999).

It is important to note that teachers' conceptions may not be easily classified into solely instrumentalist, Platonist, or mathematical problem-solving perspectives and that their classroom practices may not align well with their stated beliefs. Kitchen, DePree, DePree, Celedón-Pattichis, and Brinkerhoff (2007) found that teachers at highly effective schools in low-income communities often expressed multiple perspectives on the teaching and learning of mathematics and their classroom practices reflected these multiple perspectives. According to Thompson (1992), teachers may hold multiple perspectives that helps explain why they express one philosophical view while practicing another.

Teachers' Conceptions of Student Diversity

The existing knowledge base for promoting academic achievement with a culturally and linguistically diverse student population is limited and fragmented, in part because disciplinary knowledge and student diversity have traditionally constituted separate research agendas (Lee, 1999). In recent years, studies considering the interaction between academic disciplines and students' linguistic and cultural experiences have begun to emerge in mathematics education (e.g., Civil, & Andrade, 2002; Gutiérrez, 2002). In this review of the research literature, two areas related to student diversity in mathematics education are considered: (a) teacher expectations and (b) culturally relevant instruction.

Teacher expectations. Teachers hold varied conceptions pertaining to students, including students' potential for success, cultural backgrounds, strengths and weaknesses, and future placement in society. High expectations are lauded as a key to successful teaching of students often underserved by schooling (Lipman, 1998; Zeichner, 1996). Zeichner (1996) argued that high expectations are a necessary attribute of classrooms that have the potential to narrow the achievement gap in urban schools. The research literature contains a growing consensus about what teachers need to be like, to know, and to be able to do in order to teach all students to high academic standards. This vision rests on teachers believing that all students can learn and taking the responsibility for this task regardless of students' economic circumstance or skin color. The belief that "all children can learn" and advocacy for high expectations have become part of mainstream educational rhetoric.

Although high expectations are necessary for effective teaching, they are far from the norm—especially with racial/ethnic minorities and low socio-economic status (SES) students. Teachers hold lower expectations for students of color and the poor than they do for White middle-class students (Ferguson, 1998; Grant, 1989; Knapp & Woolverton, 1995; Zeichner, 1996). Low expectations are believed to be at the root of ineffective pedagogy with students of color and the poor. Low expectations appear to result in transmission, authoritative, and controlled forms of pedagogy emphasizing basic skills (Haberman, 1991; Knapp & Woolverton, 1995). Ladson-Billings (1994) described how some teachers expect African American students to be more difficult to control, and therefore work harder at restraining these students in the classroom. In their review of social class and schooling, Knapp and Woolverton (1995) claimed that controlled forms of instruction teach low-SES students that little is expected from them except compliance to a rigid classroom environment. This "pedagogy of poverty" (Haberman, 1991) is prevalent in urban and/or low-SES schools.

Culturally relevant instruction. Teachers who believe that all children can learn may have high expectations but may not necessarily provide culturally relevant instruction if they teach only dominant content but ignore issues of culture. Notions of culturally relevant instruction embrace the significance of high expectations but move beyond it to highlight the significance of culture and power as both a means to an end and goals in and of themselves. Culturally relevant instruction views student culture and cultural experiences as a strength and use this knowledge as a bridge to learning (Ladson-Billings, 1994, 1995).

Because mathematics tends to be presented as a set of objective and universal facts and rules, it is often viewed as "culture free" and not considered as a socially and culturally constructed discipline (Banks, 1993; Peterson & Barnes, 1996; Secada, 1989). Instructional practices have traditionally relied on examples, analogies, and artifacts that are often unfamiliar to non-mainstream students (Ninnes, 2000). Recent efforts to provide culturally relevant instruction indicate that when their cultural and linguistic experiences are used as intellectual resources, non-mainstream students are able to engage in academic learning and show significant achievement gains. For example, the Algebra Project (Silva & Moses, 1990) uses student knowledge of the subway system as a basis for understanding operations with integers. The focus on student strengths contrasts the remediation model of teaching urban students, in which curriculum and instruction are predicated on what students do not know and often emphasize rote skills (Haberman, 1991; Oakes, 1990).

Methods

Research Setting and Teacher Participants

District selection. The study was conducted in two areas that had previously received Urban Systemic Initiative[1] funding from the National Science Foundation, "President City Area[2]" and "Arbor City." Because President City consisted of three adjacent school districts with similar characteristics, we refer to it as the "President City Area."

The Arbor City school district and three contiguous President City Area school districts were chosen to participate in this study because they served large low-income and minority student populations; had on-going mathematics education reform efforts underway; adhered to standards in mathematics, science, and language arts; and gave standardized tests to 4th graders in mathematics and language arts. All four districts used standardized criterion-referenced tests[3] (henceforth referred as the "State Assessment") to evaluate 4th graders in mathematics and language arts.

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[1] The National Science Foundation launched its Urban Systemic Initiative (USI) program in 1994, applying lessons learned from its earlier Statewide Systemic Initiative program to the problems of inner-city school systems. The USI program was offered to 25 major cities with the largest number of K–12 students living in poverty.

[2] Names of participating cities are pseudonyms.

[3] In Arbor City, 4th graders were tested with the Stanford Achievement Test-9th (SAT9) Edition: Intermediate I. Fourth graders in the President City Area were tested with the State Assessment of Academic Skills.

Arbor City, one of the nation's oldest cities, contained over 170 elementary schools. At the time the study was undertaken in 2000, the majority of the public school district's more than 200,000 students were African American (65%), with approximately equal numbers of White (16%) and Hispanic/Latino (13%) students. Students in the public schools were predominantly low-income; 80% were eligible for free or reduced-price lunch. In Arbor City, 62% of the teachers were White, 36% African American, and 1% Hispanic/Latino.

The President City Area schools, comprised of three contiguous districts, contained 116 elementary schools. Of over 103,000 public school students, 85% were Hispanic; 11% White; and 3% African American. Over 26% of these districts' students were limited English proficient/English for speakers of other languages (LEP/ESOL); nearly 70% qualified for free or reduced-price lunch. At all but one of the President City Area schools, the majority of teachers were Hispanic/Latino/a (60% or more). At all but this one school, 49 to 74% of the teachers reported the ability to speak fluent Spanish.

School selection. To be selected for inclusion in this study, elementary schools had to meet two sets of criteria. First, in terms of demographic criteria, an elementary school had to serve predominately minority, low-income students. At least 50% of the students of a school's population had to be low-income as defined by the district. Second, in terms of academic criteria, at schools that were designated as highly effective across the four participating districts, 90% or more of students were tested with the State Assessment. Additionally, student test scores in mathematics and science at the fourth-grade level from 1996 through 1999 were either increasing or were consistently high. This requirement reduced the likelihood that a school considered highly effective one year would fall below the threshold the next year—a common finding in the effective schools literature (Good & Brophy, 1986). Finally, highly effective schools had to be among those with the highest percentage of 4th grade students scoring at Basic or above in Reading in their district in 1999.

In Arbor City, criteria to select highly effective schools also included:

- 66% or more of the 4th graders tested scored at Basic or above in mathematics, and
- 30% or more of the 4th graders tested scored at Proficient or above in mathematics.

In the President City Area, criteria to select highly effective schools also included:

- 90% or more of the 4th graders tested scored at Passing or above in mathematics,
- 50% or more of the 4th graders tested scored at Proficient or above in mathematics, and

- 30% or more of a school's students were Limited English proficient (LEP).

Based on the two sets of criteria described above, three schools were selected as typical schools matched to the five highly effective schools in both Arbor City and in the President City Area, respectively. Typical schools were in the same district-administrative unit, called a cluster, as a highly effective school to ensure that the schools were in the same geographic region of the city and had similar access to professional development activities. They enrolled approximately the same percentage of low-income students and had approximately the same racial and ethnic breakdown. To the degree possible, typical schools and highly effective schools enrolled a similar number of students. One school that was initially selected as a highly effective school in Arbor City was re-designated as a typical school because in 2000 their SAT9 scores plummeted and remained very low in 2001. All selected schools were given a $600 incentive for participation.

Teacher selection. We selected fourth grade as the target because restricted resources limited us to studying a single grade. Schools had been selected as highly effective or typical based on the achievement of their fourth graders, and fourth is also the grade when National Assessment of Education Progress (NAEP) testing is done. Principals at participating schools were asked to make a list of the fourth grade teachers in their schools who taught both mathematics and science. Then, they ranked the teachers from "most effective" to "least effective" according to some explicit criterion, such as a recent job evaluation. In both the President City Area and Arbor City, two teachers per school were selected to participate in this study based on their being at neither extreme of the principal's ranking. Thus, a total of 32 teachers took part in the study (16 from each city), including 20 from highly effective schools and 12 from typical schools across the two cities.

Data Collection

The data collection team consisted of three mathematics educators, including one who was involved in the development of the classroom observation instrument and one who had extensive experience in using this instrument. No one associated with this study was aware of which schools were highly effective and which were typical until the results were aggregated at the level of school effectiveness. Data collectors visited each school twice during a single year—once in the fall and once in the spring. During each visit, each participating teacher was observed teaching twice—two distinct lessons on consecutive days, for a total of four observations of each of the 32 participating teachers in the sample.

We conducted semi-structured interviews with each teacher immediately after the two classroom observations. Each of the 32 teachers in the sample was to have been interviewed twice; however, due to teacher absenteeism, we finished 56 of 64 possible interviews for the study. We obtained copies of academic tasks (e.g., handouts) during classroom observations, and then used these tasks and classroom activities as the context to examine teachers' conceptions during interviews. In addition, the concrete and immediate nature of the tasks and activities facilitated interviews with the teachers.

To examine teachers' conceptions (knowledge and beliefs) of mathematics education with student diversity, our semi-structured interview protocols were adapted from existing instruments (Newmann, Secada, & Wehlage, 1995). During fall 2000, interviews were designed to examine teachers' (a) general perceptions of the lessons, (b) conceptions of the nature of mathematics, (c) conceptions of student diversity, and (d) conceptions of integrating mathematics with student diversity (see Appendix I for Fall 2000 teacher interview protocol). During spring 2001, interviews were designed to examine teachers' (a) general perceptions of the lessons, (b) influences of high-stakes assessments and accountability on classroom practices, (c) understanding of individual students' strengths and weaknesses, and (d) use of instructional strategies to meet students' learning needs in mathematics (see Appendix II for Spring 2001 teacher interview protocol). Each question was followed with probes. Each interview lasted about 45 minutes to 1 hour. All the interviews were audio-taped and transcribed.

Data Analysis

The teacher interview transcripts were initially read as a complete dataset and coded for structural categories according to classroom data, interview questions, individual questions, students, and schools. With the use of NUD*IST, this structure provided the initial database, allowing for flexible grouping and coding of teachers' conceptions. Data were sorted by interview questions to examine (a) teachers' conceptions of curriculum, instruction, and assessment in mathematics and (b) teachers' conceptions of student diversity in mathematics. Then, for each of (a) and (b), the data were sorted by district (President City Area and Arbor City).

The data subsets were analyzed using interpretive methods (Erickson, 1986). Each data subset was read as a whole, followed by a period of open coding to allow for the emergence of themes. An iterative process of coding, memo writing, focused coding, and integrative memo writing followed (Emerson, Fretz, & Shaw, 1995). Creation of the codes went through multiple revisions, as the data were repeatedly read to check the consistency of themes. This process continued until either no new categories were developed or consistency was achieved. After we obtained the set of themes from the dataset, we searched for commonalities and differences in teachers' responses between highly effective and typical schools with respect to each of the themes. We sought both confirming and disconfirming evidence by searching for supportive and non-supportive evidence (Erickson, 1986). We considered teachers' conceptions in each city to be replication of the other.

Results

The results about teachers' conceptions are grouped into (a) mathematics in terms of curriculum, instruction, and assessment and (b) student diversity in terms of teachers' expectations and understanding of culture. Frequencies (%) of teachers' responses for each key theme are presented; on occasion, an illustrative example is presented to clarify a theme.

Teachers' Conceptions of Mathematics Curriculum, Instruction, and Assessment

We investigated elementary teachers' conceptions of mathematics curriculum, instruction, and assessment between highly effective and typical schools. Findings are presented in Table 1.

Teachers' conceptions of mathematics curriculum. We identified two themes that differentiated teachers at highly effective and typical schools across the two cities: (a) student knowledge of addition and subtraction facts and (b) teaching more content than simple problem solving and basic facts.

Teachers at highly effective schools were *less concerned* about their students knowing the basic addition and subtraction facts (i.e., could recall sums and differences of two single-digit numbers). In contrast, the majority of teachers at typical schools included basic addition and subtraction as among the most important mathematical ideas that they believed they should teach. In the President City Area, a higher percentage of teachers from typical schools (67%) prioritized teaching students basic addition and subtraction skills compared to only 30% of teachers from highly effective schools. In Arbor City, all but one of the teachers from typical schools (93%), but only 25% of teachers from highly effective schools identified the importance of students knowing their basic addition and subtraction facts. Because we did not study students' prior educational experiences in mathematics, we do not know if this difference can be attributed to students at highly effective schools having access to a more challenging mathematics curriculum.

Table 1
Teachers' Conceptions of Mathematics Curriculum, Instruction, and Assessment

	Theme	School Type	President City Area	Arbor City
Curriculum	Basic skills	Highly Effective	30%	25%
		Typical	67%	93%
	Teaching more than problem solving and basic facts	Highly Effective	90%	50%
		Typical	67%	67%
Instruction	Make meaning of mathematics	Highly Effective	40%	7%
		Typical	17%	0%
	Multiple instructional strategies	Highly Effective	30%	50%
		Typical	33%	0%
	Meeting students' affective needs	Highly Effective	40%	50%
		Typical	17%	17%
Assessment	Influenced by test	Highly Effective	100%	63%
		Typical	100%	100%
	Teach beyond test	Highly Effective	63%	11%
		Typical	0%	0%

Many teachers cited problem solving and basic facts (i.e., being able to operate on two single-digit numbers with the four basic operations) as among the three most important mathematical ideas to teach during fourth grade. Yet, there were noticeable differences between highly effective and typical schools in the President City Area, although such differences were not as evident in Arbor City. In the President City Area, teachers at typical schools were generally not particularly articulate about what their students needed to learn in mathematics. In contrast, 90% of the teachers from highly effective schools talked at great length about going beyond teaching only problem solving and the basic facts and identified additional mathematical ideas that they wanted their fourth graders to learn. For example, Mr. Bruno[4] from a highly effective school in the President City Area discussed the importance of his students analyzing the reasonableness of their solutions and learning algebra, geometry, and measurement:

[4] All names of participating teachers are pseudonyms.

> Reasonableness is the first thing. I want them to be able to relate to reality. The second one would be being able to work as a whole, different kinds of math problems. Multiplication, division, subtraction, even algebra, if possible, so that when they go up to higher grades or even on to college, they'll be able to perform mathematical situations in an easier way for them. I've seen many students struggle with that, so I want to make it easier for them. So, the second one is to work problems. The third one is for them to get to know measurement in every aspect—weights, length, depth, volume. Lastly, they need to get to know geometry. All those things together will make a mathematician. (Bruno, Highly Effective, President City Area)

Teachers' conceptions of mathematics instruction. Our analysis identified two themes that differentiated teachers at highly effective and typical schools across the two cities: (a) making meaning of mathematics and (b) using multiple instructional strategies.

Teachers from highly effective schools were more likely to express the importance of helping their students make meaning of mathematical ideas by engaging them in mathematical investigations. As shown in Table 1, teachers from highly effective schools across both participating cities were more likely than their counterparts at typical schools to describe helping their students make meaning of mathematics as one of their instructional strategies. Ms. James, a teacher from a highly effective school in Arbor City described a multiplication algorithm that she taught and believed helped her students develop an understanding of multiplication:

> But multiplication is where they get a new algorithm; they don't do it the traditional way. This one, they do it according to an array that they draw and according to how many sections there are in the array. That is the way the algorithm is broken down and they have to explain each section. So this algorithm is much longer and it's detailed but it shows you exactly what steps you went through…. And it helps you understand the value of the number as opposed to 'why am I doing this' or just going through a process and not understanding why you're doing it. (James, Highly Effective, Arbor City)

In Arbor City, a significantly higher percentage of teachers from highly effective schools (50%) than teachers from typical schools (0%) discussed the importance of implementing multiple instructional strategies. This finding was not replicated in the President City area.

Ms. Birge, another teacher from a highly effective school in Arbor City, explained how her instruction changed as the academic year progressed to emphasize students justifying their ideas while problem solving in groups:

> I just keep plugging at it. Every lesson that I teach, tell me how you came up with that. Well, the answer is wrong. It doesn't matter; what made you say that? They also have math journals, which you didn't get a chance to see. In their math journals, they'll start to write more about how to solve problems and what they took from their

> problem and, more importantly, how it relates to everyday life…. They don't even do as much group work now as they will in the coming months. And that's when I really get to see how you think. So right now, all of them are doing relatively well but this is skill stuff. This is not really digging in—the meat and gravy of it, just the top layer. (Birge, Highly Effective, Arbor City)

Teachers' conceptions of mathematics assessment. The teachers in this study were forthright about the influence of standardized testing on their mathematics curriculum and instruction. Our analysis identified two themes that differentiated teachers at highly effective and typical schools across the two cities: (a) influenced by test, and (b) teaching beyond test.

In the President City Area, all of the teachers described how their mathematics instruction was strongly influenced by the mathematical content of the State Assessment. They were candid that their assessment goal was to learn what mathematical topics students needed to study to prepare for the State Assessment. They were expected to get specific training to prepare their students to be successful on the State Assessment. This expectation appeared to be particularly true for teachers from typical schools, most of whom described attending the Evaluation Program workshops focused exclusively on preparing students for success on the State Assessment. Interestingly, 30% of teachers from highly effective schools, but no teacher from a typical school, challenged using only the Evaluation Program curriculum.

A significant finding was that none of the teachers from the typical schools in the President City Area discussed how their mathematics instruction went beyond simply preparing their students to be successful on the test. In contrast, 63% of teachers from highly effective schools stated that they were either more concerned about teaching to the state curriculum framework than preparing their students to be successful on the State Assessment or that they tried to do more than simply teach to the test. Ms. Padron described how she taught to the state curriculum framework:

> I always use my bible, which is my state curriculum framework, and that's aligned to the State Assessment….It's our state curriculum and we have to go by that. And that's what the State Assessment also tests, but sometimes....I tell them that we're not learning just because of the State Assessment….We go beyond that. We do more than that. That's just the minimum that you should know. (Padron, Highly Effective, President City Area)

The Arbor City teachers devoted considerable time to developing and implementing lessons to prepare students to be successful on the district's test. Few teachers alluded to how they worked to teach beyond the learning objectives of the test.

Summary. The main themes that emerged in our analysis of the participating teachers' conceptions of mathematics curriculum, instruction, and assessment involved: (a) the mathematics content that should be taught, (b) the instructional strategies that should be used for lessons, and (c) the influence of standardized testing. Teachers from highly effective schools across the two cities expressed more elaborate conceptions (i.e., conceptions aligned with recommendations found in the mathematics education reform literature) with respect to these themes and others (see Table 1). Though teachers across both cities were under pressure to prepare students to be successful on a standardized test in mathematics, teachers at highly effective school expressed more elaborate beliefs and knowledge about mathematics, placed less emphasis on preparing their students for the test (in the President City Area), and implemented more diverse instructional strategies (in Arbor City) than their colleagues from typical schools.

Teachers' Conceptions of Student Diversity

In this study, we also examined and compared teachers' conceptions with regards to student diversity across highly effective schools and typical schools. Findings are summarized in Table 2.

Teacher expectations. Four themes differentiated teachers at highly effective and typical schools across the two cities with regards to teacher expectations: (a) high-level thinking, (b) academic excellence, (c) academic potential of a low achieving student, and (d) expectation of attending college.

First, high-level thinking (HLT) in mathematics includes reasoning, problem solving, evaluating, predicting, synthesizing, making connections, building models or simulations, and communicating about the content (NCTM, 2000; NSF, 1996). The emphasis is on students engaging in these high-level cognitive processes as they make sense of mathematics by connecting new to existing knowledge and learn content with understanding (see, e.g., Hiebert & Carpenter, 1992; Lampert, 1990). Teachers' comments about high-level thinking fell into three sub-themes, including student generated solutions, mathematical inquiry, and logical or mathematical reasoning. The more common of these responses was student-generated solutions; some teachers described students deriving alternative solution strategies that had not been taught by the teacher:

> Sometimes it takes awhile and then they have a whole different way of doing it. I will show them the math way and they would show another way and I would be like wow! I never thought of it that way then again I don't know how a 9-year-old mind works so yeah, they surprised me. It is nice when it happens you know. (Haney, Typical, President City Area)

Table 2
Teachers' Conceptions of Student Diversity

	Theme	School Type	President City Area	Arbor City
Teacher expectations	High level thinking	Highly Effective	89%	30%
		Typical	20%	33%
	Academic excellence	Highly Effective	78%	60%
		Typical	60%	83%
	Academic ability of low-achieving student (low)	Highly Effective	22%	0%
		Typical	40%	33%
	College attendance	Highly Effective	100%	57%
		Typical	100%	17%
Culture	Cultural connection	Highly Effective	60%	50%
		Typical	50%	17%
	Multicultural curricula	Highly Effective	60%	30%
		Typical	33%	33%
	Not culture	Highly Effective	50%	70%
		Typical	83%	83%

HLT was a strong distinguishing factor between teachers from highly effective and typical schools in the President City Area. Most of the teachers from highly effective schools (89%) saw HLT as strengths compared to 20% of teachers from typical schools. HLT was less prominent with the Arbor City teachers, with about one-third of the teachers from both groups citing HLT.

Second, teachers' efforts to promote learning or raise achievement beyond what was expected in the standard curriculum were coded under academic excellence. This term is consistent with Ladson-Billings' (1994) notion of academic excellence as a core component of culturally relevant pedagogy. Strategies that teachers stated they used to promote academic excellence included (a) differentiating instruction, (b) pushing students to strive academically, and (c) referring students to gifted and talented programs. Similar to the HLT analysis, there were differences with regards to academic excellence across districts. In the President City Area, teachers from highly effective schools (78%) were more likely to promote academic excellence than teachers from typical schools (60%). The opposite was true for Arbor City, with 60% from highly effective schools and 83% from typical schools respectively.

The third signifier of teachers' expectations involved their beliefs about student ability. Teachers who exhibit high expectations believe that students have the potential to succeed (Ladson-Billings, 1994). The results show some variation in teachers' expectations of a low-achieving student with regard to student behavior including good or poor academic performance, potential for success, and descriptors of the student (e.g., smart). Of these three, the most frequent comments involved academic performance. Across the participating districts, teachers at typical schools were more likely than their counterparts at highly effective schools to state that students they had designated as "low" had less potential for academic success than their other students.

Finally, an analysis of the data shows differences in expectations for college attendance between the two cities. All teachers from the President City Area (highly effective and typical) stated that they believed a majority, if not all, of their students would attend college. Such was not the case with Arbor City. Instead, teachers often cited the negative influences of students' neighborhoods and lack of college-educated role models as barriers to college attendance. Nevertheless, teachers from highly effective schools (57%) were more likely to see college as an attainable goal for many of their students compared to teachers from typical schools (17%).

Culture. The culture analysis is an examination of teachers' conceptions of students' cultures (including race, ethnicity, language proficiency, and social class), the influence of culture on teachers' practices, and the relationship of culture to achievement. Three themes emerged from our analysis: (a) cultural connection, (b) multicultural curricula, and (c) not culture. With the exception of multicultural curricula, these themes were not specific to mathematics but encompass education issues generally.

First, some teachers commented on sharing cultural characteristics with students. The teachers described cultural connections in terms of race/ethnicity, shared language (Spanish), and common life experiences:

> One of the ways that I win the parents over is by having a conference with the family. Once they see that I am interested in their culture—it's my culture too. It's my background too. I let them know how I learned Spanish because I had a blind grandmother and she just corrected me as I went along....I think that I've been able to help the students not only be successful, but I've been able to reach them….I'm very much a part of them. (Mercado, Highly Effective, President City Area)

Across the two cities, teachers from highly effective schools were more likely than teachers from typical schools to mention connecting culturally with students. The difference among teacher groups was greater in Arbor City (50% versus 17%) than the President City Area (60% versus 50%).

Second, some teachers talked of incorporating culture into the teaching of mathematics. The most common strategy was situating mathematics within contexts that were familiar to students from either a personal or cultural perspective. The purpose of this strategy was to promote meaning and understanding of the content:

> My example that I give them, when we got to Mexico. Because the kids have been to Mexico. Is there only one way to get to Mexico? Well, no. We go by the freeway, we go through the downtown, we take this bridge, so I say how many ways is that? Like five. That's the way you do the math. There are different ways to get to the answer. When we get to Mexico, we just don't go the same way. There are different ways and you can still get to Mexico. So in math, there are different ways to get to the answer. So they laugh about it. But they remember it. (Rincon, Highly Effective, President City Area)

Another strategy was to infuse into the curriculum current professional or historical figures in mathematics who come from diverse backgrounds. In President City, teachers from highly effective schools were almost twice as likely (60%) to embed multicultural curricula aspects into their instruction of mathematics than teachers from typical schools (33%). This difference was not found in Arbor City where the rates were relatively equal at 33%.

Finally, a major theme involved teachers' statements that culture does not play a significant role in learning in general or the teaching and learning of mathematics (i.e., "not culture"). As alternatives, teachers offered "kids are kids," or the universality of mathematics as significantly affecting achievement. Across both cities, teachers from typical schools were more likely than teachers from highly effective schools to state that culture was not a significant influence on learning (83% versus 50% in President City Area, and 83% versus 70% in Arbor City). However, when we examined subthemes, the "kids are just kids" subtheme emerged as the most significant:

> I really try hard not to make it an issue of English and Spanish or Hispanic or non-Hispanic. That is not the issue. The issue is that you are a child in this world that has value. (James, Highly Effective, Arbor City)

Summary. The principal themes that emerged in our analysis of the participating teachers' conceptions of student diversity involved: (a) teachers' academic and future expectations for their students, and (b) teachers' conceptions of students' cultures. Teachers from highly effective schools across the two cities expressed more elaborate conceptions (i.e., conceptions aligned with recommendations made by researchers in multicultural education) with respect to these themes and others (see Table 2). Teachers at highly effective schools across the two districts were more likely to state that all their students had potential for academic success. In addition, teachers from highly effective schools were more likely than teachers from typical schools to report sharing a cultural connection with students and this difference was greater in Arbor City than in the President City Area. Lastly, while multicultural curricula did not distinguish the teacher groups in Arbor City, teachers at highly effective schools in the President City Area were almost twice as likely as teachers at typical schools to state that they used cultural contexts or cultural icons to teach mathematics.

Discussion and Implications

A guiding principle for this study was that teachers at highly effective schools possess desirable characteristics or engage in desirable instructional practices more so than teachers at typical schools. While other research has focused on non-instructional, school-level characteristics (Edmonds, 1979; Martin et al., 2000; Purkey & Smith, 1983), in this study we focused on teacher conceptions of mathematics and student diversity. Following the literature on school restructuring (Lee & Smith, 2001; Newmann and Associates, 1996), we set out to examine how teachers in highly effective schools articulated their learning goals in mathematics for diverse student groups in comparison to their colleagues at typical schools.

Major Findings and Relevant Findings

The research findings help to explain the differentiation between highly effective and typical schools.

Finding #1: We found consistent evidence that teachers at highly effective schools expressed more elaborated conceptions of mathematics education than teachers at typical schools. Across the two cities, teachers at effective schools stated that mathematics is more than just addition and subtraction, that instruction should help students make sense of mathematics, and that they employ multiple instructional strategies.

While all teachers acknowledged that their curricular decisions were heavily influenced by high-stakes mathematics tests, the effective schools' teachers were more likely to state (very eloquently, at times) that they tried to teach beyond the test. Furthermore, teachers at effective schools in the President City Area tried to incorporate more advanced mathematics content in their fourth-grade curriculum. These teachers' conceptions were more aligned with the Platonist view (Hiebert & Carpenter, 1992) or the problem-solving view (Ball & Cohen, 1999) of mathematics than the instrumentalist view.

Finding #2: We found evidence that teachers at highly effective schools possess more elaborated conceptions involving student diversity than teachers at typical schools. For instance, teachers at highly effective schools across the two cities advocated for explicitly including multicultural referents in the curriculum, whereas teachers at typical schools expressed ideas to the effect that mathematics is a culturally neutral subject.

Interestingly, but unexpectedly, teachers' conceptions of student diversity varied by city. In the President City Area, teachers at highly effective schools couched their conceptions in terms of *teacher expectations* of their students. The teachers emphasized students' higher order thinking in mathematics, tried to improve academic excellence in mathematics, saw potential in low-achieving students, and expected the majority of their students to go to college (Lipman, 1998, Zeichner, 1996). In Arbor City, teachers at highly effective schools couched their conceptions in terms of their own and their students' *cultural backgrounds*. The teachers stated that they shared similar cultural backgrounds (either through race/ethnicity or upbringing) with their students, and noted that their students brought knowledge acquired in their homes and communities that could enrich or make the teaching of mathematics more meaningful (Banks, 1993; Ladson-Billings, 1994, 1995).

Discussion of the two findings: We found compelling evidence that teachers at highly effective schools have more elaborated conceptions of both mathematics education and of student diversity. In general, teachers at highly effective schools articulated more often than their counterparts at typical schools conceptions that align with recommended reforms in mathematics education and conceptions with respect to student diversity that parallel scholars' recommendations related to the constructs of teacher expectations and culturally relevant instruction. Because we did not study students' prior educational experiences, we do not know if these differences could be explained in terms of students at highly effective schools having already learned and achieved at higher levels prior to the study. Moreover, these differences did not exist for each category (e.g., teachers at typical schools in Arbor City were more likely to promote academic excellence than their counterparts from highly effective schools). Nevertheless, given the care that was taken to differentiate highly effective schools from their typical counterparts, our findings do demonstrate that differences existed between these two groups of schools with regards to teachers' conceptions of mathematics education and of student diversity.

Teachers at highly effective schools believed in the importance of teaching more than problem solving and the basic facts and stated that they used a variety of instructional strategies to help students make sense of mathematics. Teachers at highly effective schools also emphasized how they taught their students more than what was covered on the State Assessment or standardized tests. While instruction as described in the reform literature (see, e.g., NCTM, 2000; NSF, 1996) is very important, it is also the case that teachers do more than simply teach. Beyond teaching, teachers can exhort students to do well, show care for students and their parents, and provide students with reasons for staying in school and trying hard for their future lives. All of these features would seem to rely on the kinds of expectations and cultural knowledge that the teachers in our highly effective schools expressed. Thus, it seems reasonable to conclude that teachers' conceptions of student diversity, as well as their conceptions of mathematics education, both influence student learning (Rodriguez & Kitchen, 2005; Rousseau & Tate, 2003). Our results are certainly consistent with such a view.

Highly effective teachers who participated in this study not only expressed high expectations for their students and/or valued their students' cultural backgrounds, they also talked about their desire to utilize mathematics curricula and implement instructional strategies aligned with reforms in mathematics education. It was beyond the scope of this study to determine whether causality existed between differing teachers' conceptions, such as how teachers' conceptions about student diversity may influence their conceptions about mathematics education. Nevertheless, this study motivates questions about the interaction between teachers' conceptions about mathematics education and student diversity.

The results also suggest the need for a more nuanced analysis of how variation in student backgrounds could result in variations in teachers' responses to those backgrounds. In this study, teachers at highly effective schools in the President City Area, many of whom shared the same cultural backgrounds as their students, said more about their expectations for their students than their shared backgrounds and shared experiences. In contrast, teachers at highly effective schools in Arbor City reported relying on their shared cultural backgrounds more than they discussed the kinds of expectations they had for their students. Both groups of teachers, however, were very similar in their more elaborated conceptions of the teaching of mathematics with diverse student groups than teachers at typical schools.

Implications for Teaching and Teacher Development

To promote reform oriented instruction in mathematics, professional development efforts should involve helping teachers develop deep understanding of content knowledge, foster students' initiation and exploration in problem solving, identify students' mathematical conceptions and misconceptions, and implement content-specific teaching strategies (Garet, Porter, Desimone, Birman, & Yoon, 2001; Richardson & Placier, 2001). This need is great with elementary teachers in mathematics, because they are generally not adequately prepared with content knowledge or effective teaching practices.

By their comments, many teachers in the study displayed limited knowledge of how to incorporate students' linguistic and cultural diversity into mathematics instruction. Some teachers, especially in typical schools, considered mathematics as "culture-free." In contrast, teachers in highly effective schools made statements about student diversity that could serve as a basis for the provision of professional development. That is, professional development should involve enhancing teachers' knowledge of student diversity and the intersections of culture and language with teaching practices and student achievement. Such an effort may involve diversifying and tailoring professional development efforts to the specific challenges that different groups of teachers face with their students. For example, "pedagogy of poverty" (Haberman, 1991) may need to be addressed in Arbor City, whereas issues of English language learners should be integrated in the President City Area (Moschkovich, 1999).

Recommendations for Further Research

This study provided an in-depth analysis of fourth-grade teachers' conceptions across schools in geographically distinct areas. The focus on differences in teachers' conceptions affords one way to examine why some schools are more effective than others. Our data, however, did not provide the means to understand how significant a role teachers' conceptions actually are in differentiating highly effective schools from their more typical counterpart. Research needs to be undertaken to understand the significance of teachers' conceptions in distinguishing schools. Furthermore, research needs to be carried out to examine the relationship between teachers' conceptions about mathematics education and student diversity. If teachers have more elaborate conceptions about the teaching and learning of mathematics, are they more likely to develop more elaborate conceptions towards student diversity and vice versa?

Effective instruction requires both content coverage and reform-oriented teaching practices. Teachers at highly effective schools repeatedly stated that they taught more than what was covered on the State Assessment or standardized tests, and their conceptions of the mathematics curriculum were more elaborate than those of typical schools' teachers. The results of this study suggest that future research should examine teachers' content coverage and seek to tie the content coverage to their specific teaching practices.

High-stakes testing had a strong influence on teachers' conceptions of the teaching and learning of mathematics with diverse student groups. The results suggest that teachers believe that high-stakes tests press them to focus on teaching limited content to the exclusion of other content and constrain the instructional practices that teachers believe they can employ. Further research on how high-stakes testing influences teachers' conceptions and curriculum content coverage and how it also influences student learning and achievement seems warranted. This research topic is urgent as high-stakes assessment and accountability policy impacts more students, especially those who have traditionally been underserved in mathematics.

The research findings described here combine constructs of effective pedagogy found in mainstream mathematics education with multicultural education. Although research on academic content and student diversity rarely overlap, *both* emerged as significant in our data. These findings then beget the need for researchers, policymakers, and teacher educators to draw from multiple knowledge bases. Yet, little is known about how the constructs inform and interact with one another at the student, teacher, or school level. If research is to improve education, there is a need to develop a research agenda that combines the expertise of mainstream academic content and multicultural education researchers.

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References

Ball, D. B., & Cohen, D. K. (1999). Developing practice, developing practitioners: Toward a practice-based theory of professional education. In L. Darling-Hammond & G. Sykes (Eds.), *Teaching as the learning profession: Handbook of policy and practice* (pp. 3–32). San Francisco, CA: Jossey-Bass.

Banks, J. (1993). Canon debate, knowledge construction, and multicultural education. *Educational Researcher, 22*(5), 4–14.

Civil, M., & Andrade, R. (2002). Transitions between home and school mathematics: Rays of hope amidst the passing clouds. In G. de Abreu, A.J. Bishop, & N.C. Presmeg (Eds.), *Transitions between contexts of mathematical practices* (pp. 149–69). Dordrecht, NL: Kluwer.

Clewell, B. C., Campbell, P. B., & Perlman, L. (2007). *Good schools in poor neighborhoods: Defying demographics, achieving success*. Washington, DC: The Urban Institute Press.

Davis, P. J., & Hersh, R. (1980). *The mathematics experience*. Boston, MA: Birkhauser.

Edmonds, R. (1979). Effective schools for the urban poor. *Educational Leadership, 37*(10), 15–24.

Emerson, R. M., Fretz, R. I., & Shaw, L. L. (1995). *Writing ethnographic fieldnotes*. Chicago: The University of Chicago.

Erickson, F. (1986). Qualitative methods in research on teaching. In M. C. Wittrock (Ed.), *Handbook of research on teaching* (3rd ed., pp. 119–161). New York: Macmillan.

Ernest, P. (1988). The problem solving approach to mathematics. *Teaching Mathematics and its Applications*, *7*(2), 82–92.

Ernest, P. (1991). *The philosophy of mathematics education: Studies in mathematics education*. London: Falmer.

Ferguson, R. F. (1998). Teachers' perceptions and expectations and the Black-White test score gap. In C. Jencks & M. Phillips (Eds.), *The Black-White test score gap*, (pp. 273–317). Washington, DC: The Brookings Institution.

Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., & Yoon, K. S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal, 38*(4), 915–945.

Good, T. L., & Brophy, J. E. (1986). School effects. In M. S. Wittrock (Ed.), *Handbook of research on teaching* (3rd ed., pp. 570–602). New York: Macmillan.

Grant, C. A. (1989). Equity, equality, teachers and classroom life. In W. G. Secada (Ed.), *Equity in education* (pp. 89–102). London: Falmer Press.

Gutiérrez, R. (2002). Beyond essentialism: The complexity of language in teaching mathematics to Latina/o students. *American Educational Research Journal*, *39,* 1047–1088.

Haberman, M. (1991). The pedagogy of poverty versus good teaching. *Phi Delta Kappan, 73,* 290–294.

Hiebert, J., & Carpenter, T. P. (1992). Learning and teaching with understanding. In D. Grouws (Ed.), *The handbook of research on mathematics teaching and learning* (pp. 65–97). New York: Macmillan.

Hiebert, J., Carpenter, T. P., Fennema, E., Fuson, K., Human, P., Murray, H., Olivier, A., & Wearne, D. (1996). Problem solving as a basis for reform in curriculum and instruction: The case of mathematics. *Educational Researcher, 25*(4), 12–21.

Kitchen, R.S., DePree, J., Celedón-Pattichis, S., & Brinkerhoff, J. (2007). *Mathematics education at highly effective schools that serve the poor: Strategies for change*. Mahwah, NJ: Lawrence Erlbaum Associates.

Knapp, M. S., & Woolverton, S. (1995). Social class and schooling. In J. Banks & C. Banks (Eds.), *Handbook of research on multicultural education* (pp. 548–569). New York: Macmillan.

Kulm, G. (1994). *Mathematics assessment: What works in the classroom.* San Francisco: Jossey-Bass.

Ladson-Billings, G. (1994). *The dreammakers: Successful teachers of African American children.* San Francisco: Jossey-Bass.

Ladson-Billings, G. (1995). Toward a theory of culturally relevant pedagogy. *American Education Research Journal, 32*(3), 465–491.

Lakatos, I. (1976). *Proofs and refutations*. Cambridge, UK: Cambridge University Press.

Lampert, M. (1990). When the problem is not the question and the solution is not the answer: Mathematical knowing and teaching. *American Educational Research Journal, 27,* 29–63.

Lee, O. (1999). Equity implications based on the conceptions of science achievement in major reform documents. *Review of Educational Research, 69*(1), 83–115.

Lee, V. E., & Smith, J. B. (2001). *Restructuring high schools for equity and excellence: What works.* New York: Teachers College Press.

Lipman, P. (1998). *Race, class, and power in school restructuring*. Albany, NY: State University of New York.

Ma, L. (1999). *Knowing and teaching elementary mathematics*. Mahwah, NJ: Lawrence Erlbaum Associates.

Martin, M. O., Mullis, I. V. S., Gregory, K. D., Hoyle, C., & Shen, C. (2000). *Effective schools in science and mathematics: IEA's Third International Mathematics and Science Study*. Boston, MA: The International Study Center, Lynch School of Education, Boston College. Retrieved June 1, 2009, from http://timss.bc.edu/timss1995i/TIMSSPDF/T95_EffSchool.pdf

Moschkovich, J. N. (1999). Supporting the participation of English language learners in mathematical discussions. *For the Learning of Mathematics, 19(1)*, 11–19.

National Council of Teachers of Mathematics. (1989). *Curriculum and evaluation standards for school mathematics*. Reston, VA: Author.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics.* Reston, VA: Author.

National Science Foundation. (1996). *Indicators of science and mathematics education 1995.* Arlington, VA: Author.

Newmann, F. M., & Associates (1996). *Authentic achievement: Restructuring schools for intellectual quality.* San Francisco: Jossey-Bass.

Newmann, F. M., Secada W. G., & Wehlage, G. G. (1995). *A guide to authentic instruction and assessment: Vision, standards and scoring.* Madison, WI: Center on Organization and Restructuring of Schools, Wisconsin Center for Education Research.

Newmann, F. M., & Wehlage, G. G. (1995). *Successful school restructuring: A report to the public and educators.* Madison, WI: Center on Organization and Restructuring of Schools, Wisconsin Center for Education Research.

Ninnes, P. (2000). Representations of indigenous knowledge in secondary school science textbooks in Australia and Canada. *International Journal of Science Education, 22(*6), 603–617.

Oakes, J. (1990). Opportunities, achievement, and choice: Women and minority students in science and mathematics. In C. B. Cazden (Ed.), *Review of Research in Education*, Vol. 16 (pp. 153–222). Washington, DC: American Educational Research Association.

O'Day, J. A., & Smith, M. S. (1993). Systemic school reform and educational opportunity. In S. H. Fuhrman (Ed.), *Designing coherent educational policy: Improving the system* (pp. 250–311). San Francisco: Jossey-Bass.

Peterson, P. L., & Barnes, C. (1996). Learning together: The challenge of mathematics, equity, and leadership. *Phi Delta Kappan, 77*(7), 485–491.

Purkey, S., & Smith, M. (1983). Effective schools: A review. *The Elementary School Journal, 83*(4), 427– 452.

Richardson, V., & Placier, P. (2001). Teacher change. In D. V. Richardson (Ed.), *Handbook of research on teaching* (4th ed., pp. 905–950). Washington, DC: American Educational Research Association.

Rodriguez, A. J. & Kitchen, R. S. (Eds.) (2005). *Preparing mathematics and science teachers for diverse classrooms: Promising strategies for transformative pedagogy*. Mahwah, NJ: Lawrence Erlbaum Associates.

Romberg, T. A. (1992). Problematic features of the school mathematics curriculum. In P. W. Jackson (Ed.), *Handbook of research on curriculum* (pp. 749–788). New York: Macmillan.

Rousseau, C. & Tate, W.F. (2003). No time like the present: Reflecting on equity in school mathematics. *Theory into Practice*, 42(3), 210–216.

Schifter, D., & Fosnot, C.T. (1993). *Reconstructing mathematics education: Stories of teachers meeting the challenge of reform*. New York: Teachers College Press.

Secada, W. G. (1989). Educational equity and equality of education: An alternative conception. In W. G. Secada (Ed.), *Equity in education* (pp. 68–88). Philadelphia, PA: The Falmer Press.

Silva, C. M., & Moses, R. P. (1990). The Algebra Project: Making middle school mathematics count. *Journal of Negro Education, 59*(3), 375–391.

Thompson, A. (1992). Teachers' beliefs and conceptions: A synthesis of the research. In D. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 127–146). New York: Macmillan.

Tymoczko, T. (1986). *New directions in the philosophy of mathematics*. Boston, MA: Birkhauser.

Wiggins, G.P., & McTighe, J. (1999). *Understanding by design handbook*. Alexandria, VA: Association for Supervision and Curriculum Development.

Zeichner, K. M. (1996). Educating teachers to close the achievement gap: Issues of pedagogy, knowledge, and teacher preparation. In B. Williams (Ed.), *Closing the achievement gap: A vision for changing beliefs and practices* (pp. 56–76). Alexandria, VA: Association for Supervision and Curriculum and Development.

Appendix I
Teacher Interview Protocol
Fall 2000

At the completion of two consecutive visitations with teachers at participating schools, the interviewer/observer conducts an interview with the teacher. A primary purpose of interviews is to understand teachers' conceptions (beliefs and knowledge) about mathematics teaching and learning with culturally and linguistically diverse students. A secondary purpose is to extend the information about mathematics to other subject areas. A third purpose is to use interview responses in verifying or triangulating classroom visitations in their classrooms as well as survey responses of the entire teacher group in the research.

Interviews examine teachers': (a) general perceptions of the lessons, (b) conceptions of the nature of mathematics, (c) conceptions of students, and (d) conceptions of integrating mathematics with students. Each question is followed with probes. After a classroom visitation, the observer obtains academic tasks, such as handouts or overhead transparencies, that are used as the context for the interview. To contextualize the interviews in relation to the lessons, both the interviewer/observer and the teacher use examples of salient events during the lessons.

Teachers' General Perceptions of the Lessons

1. Do these lessons give us as a good sense of the kind of work that you typically have this group of students do in mathematics?

PROBE: If yes, how is it typical? If no, what is typical?

PROBE: Use specific incidents to probe teacher's perceptions.

2. What were the mathematical ideas that you were trying to cover during these lessons?

PROBE: Ask the teacher to define terms used, such as "topics" and "skills."

Topics – e.g., measurement, geometry, fractions
Skills (basic, low-level) – e.g., computational algorithms
Processes (higher-level) – e.g., observe, describe, classify, infer, conclude

Teachers' Conceptions of the Nature of Mathematics

3. What are <u>three</u> most important mathematics ideas for <u>your</u> students to learn in general?

PROBE: Why?

4. What determines the mathematical content that you cover during the year?

PROBE: To what extent do you rely on: textbooks, curriculum guides, standardized tests, new or innovative curricular, the standards, personal expertise, and/or beliefs about mathematics

Note: Ask the teacher to explain each of these items.

PROBE: How do the lessons fit into what you just said is important?

Teachers' Conceptions of the Students

5. Are there some students who aren't doing as well in mathematics as they should?

PROBE: Anyone who surprised you? Anyone who disappointed you?

6. Why do you think some students are doing better than you expected? Why do you think some are not doing as well as they should?

PROBE: Probe for teachers' accounts of high achievement
Probe for teachers' accounts of low achievement

7. What are you doing to meet the learning needs of these students?

PROBE: Does your instruction change during the academic year to meet your students' learning needs? If so, how?

PROBE: Probe for teacher efficacy (i.e., how teachers work to actually meet needs of students). What is the impact of your efforts on these students?

Teachers' Conceptions of Integrating Mathematics with the Students

8. Is math "culture free," or does culture have any influence on math?

PROBE: Give an example of how students' backgrounds (such as their home culture and gender) have any influence on mathematics.

PROBE: The education literature says that students from certain cultural backgrounds do not question adults at home and, therefore, do not ask questions to the teacher. What do you think about the influence of your students' cultural backgrounds on math learning?

9. Do you consider your students' culture, language, and gender in your teaching in order to promote their math learning?

PROBE: Give an example of how you used your students' cultural experiences during the lesson (if possible). (If not), give an example from your teaching at other times or during other lessons during this year of culture, gender, English language proficiency, socioeconomic status, disability.

Appendix II
Teacher Interview Protocol
Spring 2001

1. Teachers' General Perceptions of the Lesson

What were the mathematical (scientific) ideas (broad, generic sense) that you were trying to cover during these lessons?

PROBE:
Probe distinctions among topics, skills, or processes

(a) topics – e.g., measurement, geometry, fractions, biology, ecology, physical science
(b) skills (basic, low-level) – e.g., measurement, computational algorithms
(c) processes (higher-level) – e.g., measure, observe, describe, classify, infer, conclude

2. Testing

During our last visit, many teachers spoke about the impact standardized testing was having on instruction. In what ways, if any, do you feel your math (science) lesson today was influenced by state/district standardized tests?

3. For the two students who are the focus of the math (science) interview

Could we talk for a few minutes about Student A?
(Note: It will be hard for this to happen without teacher using student name.)

- Did students A do anything that surprised you during your lesson? If yes, what did the student do? Why did that surprise you?
- How well do you usually expect Student A does in math (science) in general? How well does Student A perform on math (science) tests?
- What strengths does Student A bring to math (science)? What weaknesses?
- Which, if any, strategies work particularly well with student A in math (science)? Why do you think Student A responds well to these strategies?
- Which, if any, strategies DON'T work particularly well with student A in math (science)? Why do you think Student A doesn't respond well to these strategies?
- What, if any, in and out-of-class resources do you have that can help you better teach Student A mathematics (science)?

Could we talk for a few minutes about Student B?
Go through the same procedure for Student B