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The effect of culturally relevant pedagogy on the mathematics achievement of black and Hispanic high school students

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**The Effect of Culturally Relevant Pedagogy on the
Mathematics Achievement of Black and Hispanic High
School Students**

A dissertation presented

by:

Mary L. Langlie

To

The Department of Arts and Sciences

In partial fulfillment of the requirements for the degree of
Doctor of Philosophy

In

Law, Policy and Society

Northeastern University
Boston, Massachusetts
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ABSTRACT OF DISSERTATION

Submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy in Law, Policy and Society
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Abstract

The Effect of Culturally Relevant Pedagogy on the Mathematics Achievement of Black and Hispanic High School Students

Using data from the National Educational Longitudinal Study of 1988 (NELS:88), this study examines the effect of Culturally Relevant Pedagogy on the mathematics achievement of black and Hispanic tenth grade students. Data from the Teacher Questionnaire were used to develop an index of Culturally Relevant Pedagogy for each mathematics teacher and, through standard multiple regression analysis, determine the relationship between the teacher's use of Culturally Relevant Pedagogy and the mathematics achievement of their black and Hispanic tenth grade students. Results from this study suggest that black and Hispanic students whose mathematics teachers emphasize an awareness of the importance of mathematics in everyday life, encourage their students to become interested in mathematics and encourage students to understand the applications of mathematics in the basic and applied sciences, will achieve more in mathematics.

Chapter One: Statement of the Problem

Mathematics is often considered the gateway curriculum that opens doors to college admission and, ultimately, to employability in an economic market that has become increasingly technological and global over the past fifty years. Given the role of mathematics in today's global economic and employment market, its status and functioning in K-12 education merits careful attention. It is critical that students attending public schools in the United States receive a mathematics education that prepares them for admission to college and ensures that they are employable in today's economic market. What we know, from various sources that will be reviewed in this chapter, is that students of lower socioeconomic status (those students qualifying for free or reduced-price school lunches) demonstrate lower achievement in mathematics than students of higher economic status. Students who are white do better in mathematics than students who are black or Hispanic. The consequences of this lower mathematics achievement in today's economic market are vast and, uncorrected, will perpetuate the cycle of poverty.

This chapter reviews what we know about the mathematics achievement of students from the United States when compared to students from other countries in this global economy. Performance by United States eighth-grade students in the Trends in International Mathematics and Science Study (TIMSS) 2003 will be reviewed, with an indication of how United States students compare with their peers in the forty-four countries participating in the TIMSS. This chapter will also review the performance of eighth-grade students as reflected in The National Assessment of Educational Progress

(NAEP) 2005 report of the National Center for Education Statistics (NCES), identifying differences in mathematics achievement between students in different racial and socioeconomic groups.

As referenced earlier, the impact of mathematics achievement on the lives of students in today's global and technological economy is significant. This chapter will include a review of the economy as it is evolving today relative to the increasing importance of mathematics skills for a range of professions including medicine, finance, and technology among others.

Related to a review of the role of mathematics skills on today's economy and the associated job market is a review of the role of mathematics preparation in junior high and high school. How will students' enrollment in mathematics from junior high through high school impact their ability to enroll in a four-year college and persist through graduation? Given the value of a bachelor's degree in the evolving job market, these are important considerations.

In an effort to address the lower performance of United States students in the TIMSS and the lower performance of lower socioeconomic status, black and Hispanic students in the NAEP, the National Council of Teachers of Mathematics (NCTM) has developed standards intended to bring mathematics education and mathematics achievement for all students to a level that ensures that they are able to participate in today's technological and global economy. The standards place a stronger emphasis on technology and mathematics-based skills and on learning mathematics with understanding.

The central focus of this chapter will be to review research that has attempted to identify the reasons for the disparities in mathematics achievement between students of lower and higher socioeconomic levels and between black and Hispanic and white students. Much of this research examines the impact of the NCTM principles and standards to determine their effectiveness in more evenly distributing mathematics achievement among groups, particularly minority students and students of lower socioeconomic status. This review includes a summary of the research investigating the following possible causes for the difference in mathematics achievement between low and high socioeconomic students and students within different racial/ethnic groups: tracking, curriculum, access to educational resources, student effort, teacher professional community and culturally sensitive pedagogy.

United States Performance in Mathematics Achievement Tests

United States Student Performance in Mathematics: TIMSS

The Trends in International Mathematics and Science Study (TIMSS) 2003, facilitated by the International Association for the Evaluation of Educational Achievement (IEA) is the third in this series of tests since 1995 (Gonzales, Guzmán, Partelow, Pahlke, Jocelyn, Kastberg & Williams, 2004). The TIMSS reflects the participation of more than forty countries in mathematics and science achievement testing. Although United States scores have improved with each implementation of the TIMSS, the United States continues to score below the average of a number of industrialized countries with which the United States must compete economically, in an economy dependent on technology and the associated mathematics skills of its employment base. TIMSS 2003 scores reflect mathematics achievement differently

distributed within the United States with those who are white and of higher socioeconomic levels scoring better than those who are black and Hispanic and of lower socioeconomic levels.

Chart 1 provides TIMSS 2003 scores for countries scoring higher or not measurably different than the United States.

Country	Average Score 1995	Average Score 2003	Change
Singapore	609	605	-3
Korea, Republic of	581	589	8
Hong Kong SAR	569	586	17
Chinese Taipei	--	585	
Japan	581	570	-11
Belgium – Flemish	550	537	-13
Netherlands	529	536	7
Estonia	--	531	
Hungary	527	529	2
Malaysia	--	508	
Russian Federation	524	508	-16
Slovak Republic	534	508	-26
United States	492	504	12
Lithuania	472	502	30
Sweden	540	499	-41
Scotland	493	498	5
Israel	--	496	
New Zealand	501	494	-7

Chart 1. TIMSS 2003 – Countries with scores higher than or not measurably different from United States Average.¹ (Scores in shaded area are measurably higher than those of the United States)

The TIMSS mathematics exam scores on a range from 1 – 800. The average score of eighth graders from the forty-four countries taking the TIMSS 2003 was 466, with eighth graders from the United States averaging 504. This reflects an improvement since 1995, when eighth graders from the United States scored 492 on the mathematics portion of the TIMSS.

¹ Gonzales, Carlos, Partelow, Pahlke, Jocelyn, Kastberg, & Williams. (2004). Highlights from the Trends in International Mathematics and Science Study (TIMSS) 2003 (NCES 2005-005). United States Department of Education, National Center for Education Statistics. Washington, DC: U. S. Government Printing Office.

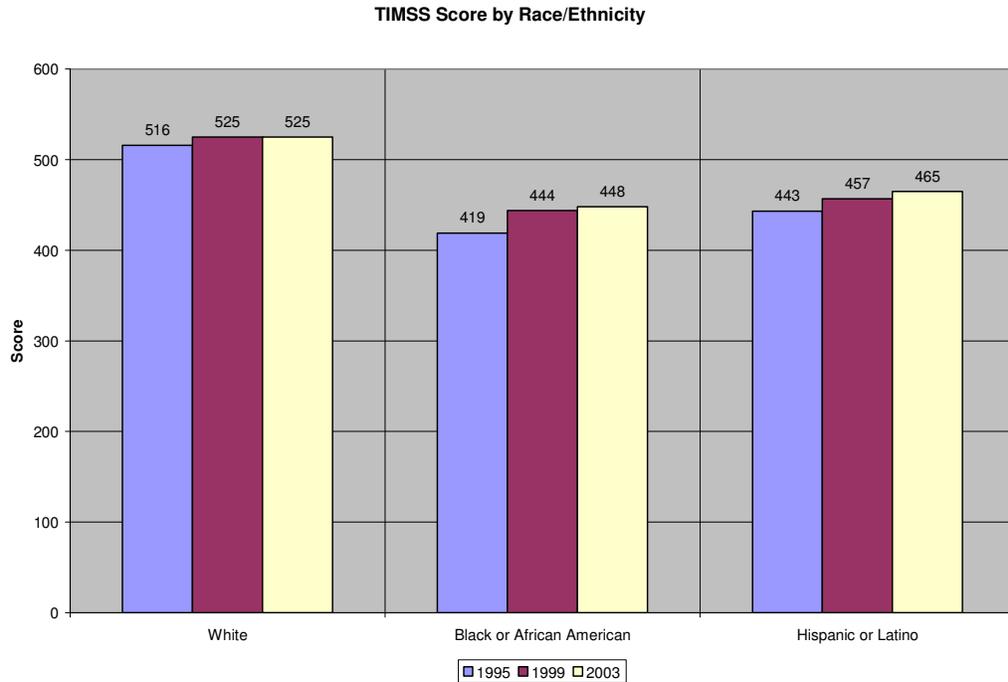


Chart 2. TIMSS 2003 – United States Scores by Race/Ethnicity

Black and Hispanic eighth graders from the United States also improved in their TIMSS mathematic score from 1995 to 2003. Eighth-grade black students' scores improved from 419 in 1995 to 448 in 2003 while eighth grade Hispanic students' scores improved from 443 in 1995 to 465 in 2003. Although this reflects an improvement, the scores of black and Hispanic students are below the United States average by 56 and 41 points respectively. Black students scored 77 points below and Hispanic students scored 60 points below whites. The differences in scores between blacks and whites and between Hispanics and whites are each statistically significant at the 95 percent confidence level.

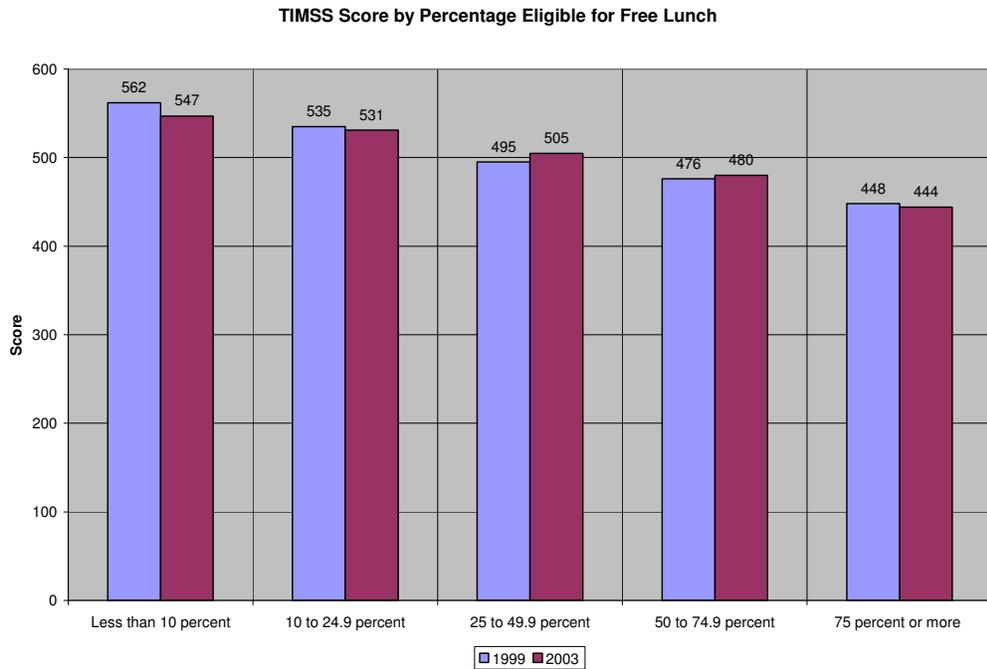


Chart 3. United States TIMSS Score by Percentage Eligible for Free Lunch

In 2003, mathematics scores also differed in the United States by socioeconomic level. Students attending public schools with 75 percent or more students eligible for free or reduced-price lunch² scored 444, while students attending public schools with 10 percent or less of their students eligible for free or reduced-price lunches scored 547, a 103 point difference. These differences in achievement are significant at the 95 percent confidence level.

The TIMSS 2003 reflects that the United States is not performing as strongly as necessary when compared with countries in the global economy with which the United States must compete in professions requiring math proficiency. United States performance in the TIMSS differs across race/ethnicity and across economic lines rather than reflecting an even distribution of mathematics achievement across the country's

² Eligibility for free or reduced-price lunch is determined by students' family income in relation to federally established poverty level.

population groups. In cases of differences in achievement between blacks and whites and between Hispanics and whites, the differences in achievement in favor of whites are statistically significant. The same is true of the differences in achievement between students of lower socioeconomic status (qualifying for free or reduced-price school lunches) and students of higher socioeconomic status. Higher socioeconomic students demonstrate a higher level of achievement in mathematics than lower socioeconomic students with the differences at a statistically significant level.

The National Assessment of Educational Progress (NAEP) - 2005

The NAEP is a nationally representative survey of student achievement in core subject areas, including mathematics. The NAEP is authorized by Congress and administered by the National Center for Educational Statistics (NCES), within the Institute of Educational Services of the United States Department of Education (Perie, Grigg, and Dion, 2005). The NAEP is often referred to as the “Nation’s Report Card™.”

The NAEP mathematics achievement test scores on a scale from 0 – 500, with levels for Eighth-Grade Achievement defined as Basic (262), Proficient (299) and Advanced (333). The United States national average score in the NAEP 2005 is 279, 20 points below the Proficient level.

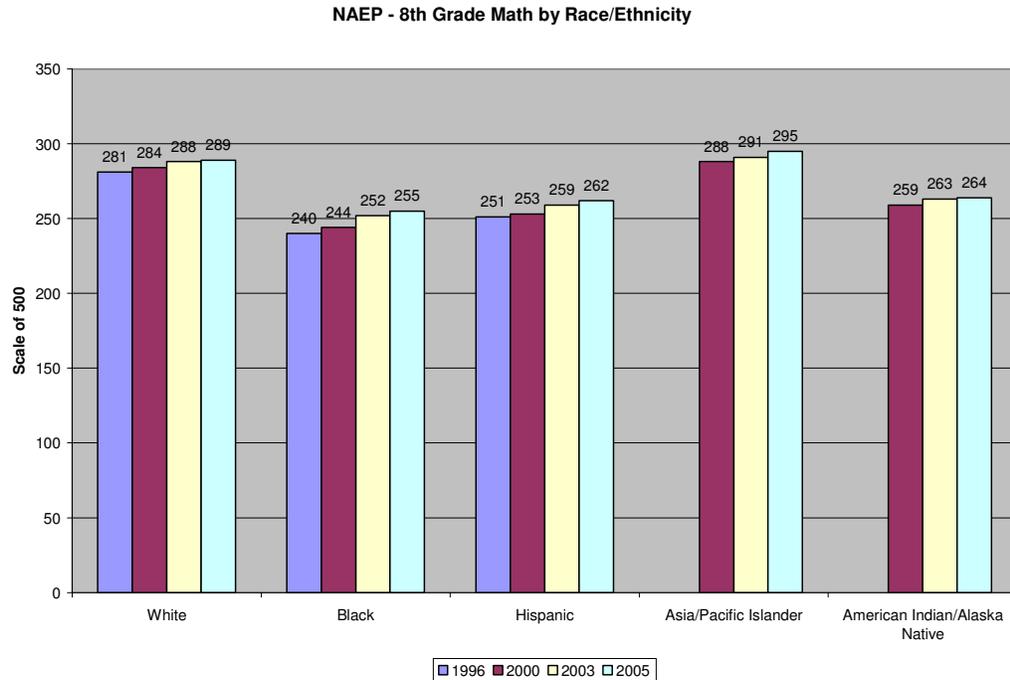


Chart 4. NAEP – 8th Grade Average Mathematics Scores by Race/Ethnicity

Although white, black, and Hispanic students' scores reflected a statistically significant increase from 2003 to 2005, blacks and Hispanics continue to reflect lower achievement than their white counterparts at a statistically significant level. This is consistent with the pattern of mathematics achievement distribution reflected in the TIMSS 2003 assessment. The gap between black and white scores was reduced from 41 points in 1996 to 34 points in 2005, not a statistically significant change. The gap between Hispanic and white scores was reduced from 30 points in 1996 to 27 points in 2005, also not a statistically significant change (Perie, Grigg, and Dion, 2005).

NAEP - 8th Grade Math Achievement by Free or Reduced-Price Lunch Eligibility

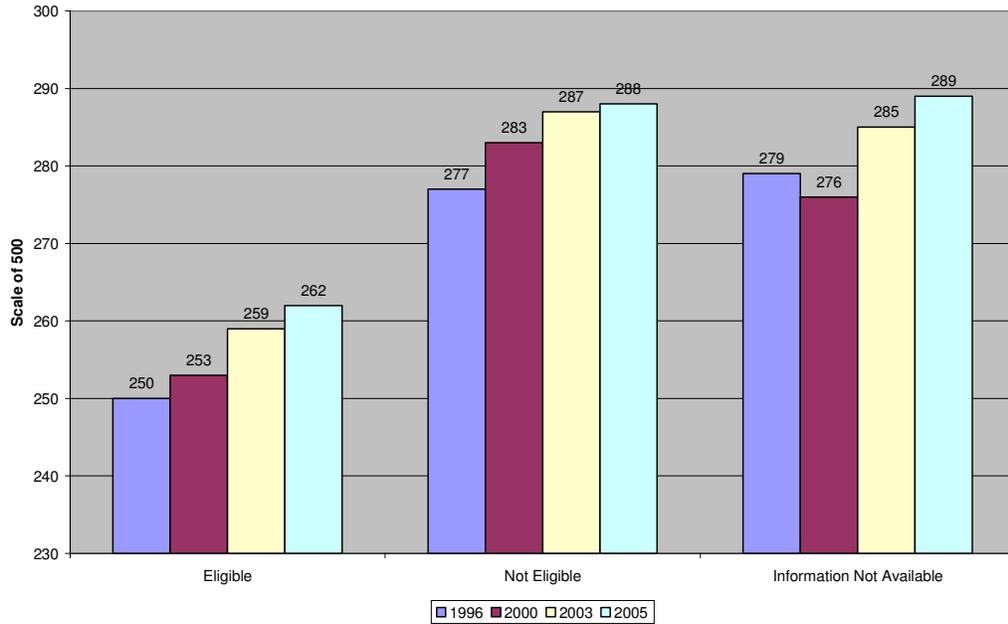


Chart 5. NAEP – Average 8th Grade Mathematics Scores – By Eligibility for Free/Reduced-Price School Lunch

As with the TIMSS 2003 study, NAEP 2005 also determines that students eligible for free or reduced-price lunch scored lower in mathematics than students who were not eligible. In 2005, those students not eligible for free/reduced-price lunch scored on average 26 points higher than those students who were eligible. This difference in mathematics achievement is also statistically significant.

NAEP 8th Grade Average Math Scores by Parents' Highest Level of Education

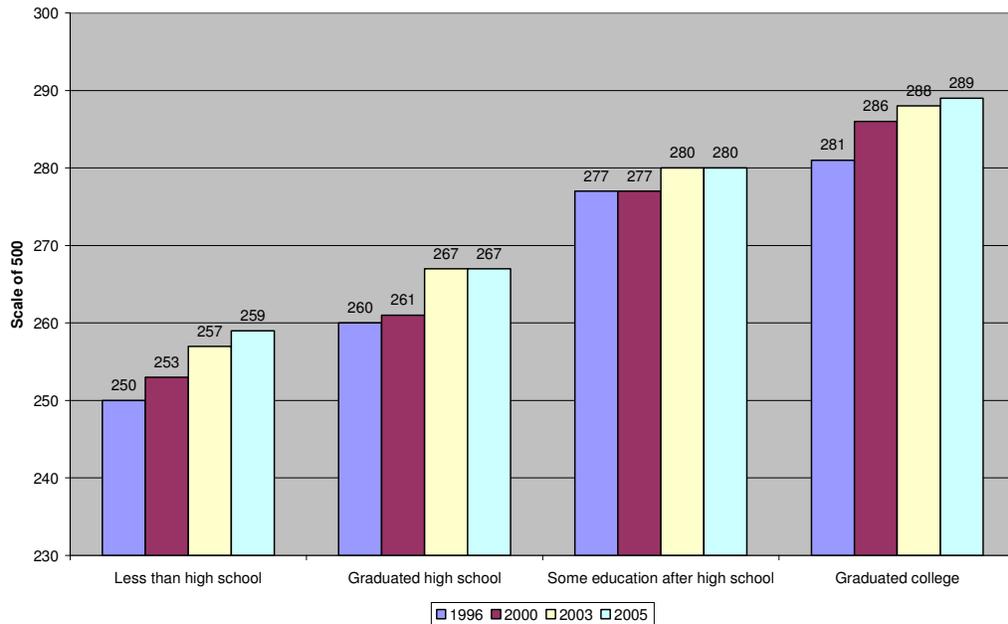


Chart 6. NAEP – Average 8th Grade Mathematics Scores – By Parents’ Highest Level of Education

NAEP data also indicate a positive relationship between the level of parents’ education and students’ mathematics achievement scores. In 2005, the average score for students whose parents did not complete high school was 259, for those who had graduated from high school was 267, for those with some education after high school was 280 and for those who graduated from college the mathematics score was 288. The difference in the score for mathematics achievement for each level is statistically significant from the next for all levels of parent education. The relevance of categorizing students by their parents’ level of education is important in that research shows that students whose parents completed a college education are more likely to attend schools that offer advanced mathematics, beginning with attending schools that offer algebra in eighth grade (Horn and Nunez, 2000; Raudenbush, Fotiu, Cheong, 1998).

In order to gain further information on the data indicating differences in achievement by type of location, in 2002, NAEP began collecting achievement data for their Trial Urban District Assessment (TUDA) category. Eleven school districts from the following urban areas participated in TUDA 2005: Atlanta, Austin, Boston, Charlotte, Chicago, Cleveland, District of Columbia, Houston, Los Angeles, New York City and San Diego. School districts participating in the TUDA are part of the “Large Central City” location category, with a population at or above 250,000 and are not synonymous with inner city (Rampey, Lutkus, and Dion, 2005).

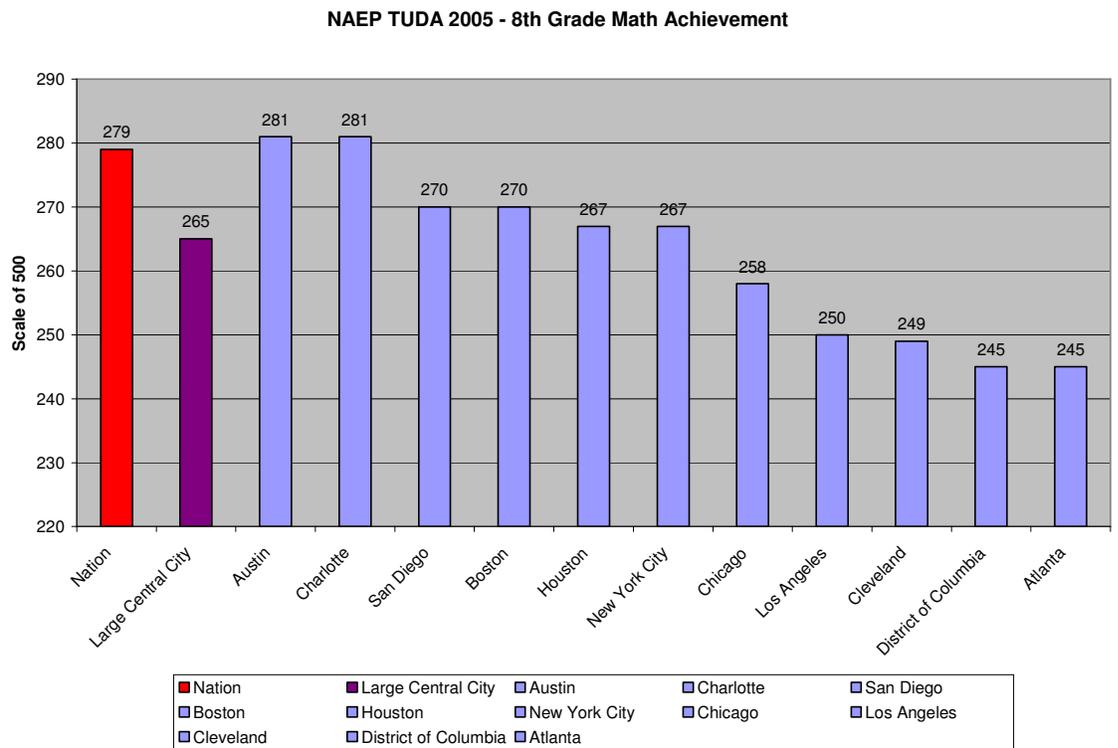


Chart 7. TUDA – NAEP 2005 - 8th Mathematics Average Scores

Chart 7 illustrates the mathematics achievement scores in the TUDA schools, in Large Central City Schools and in the nation. All school districts except Austin and Charlotte evidence a score below the national average that is statistically significant.

Austin, Charlotte, San Diego and Boston's scores are higher than those of Large Central City schools at a statistically significant level. Chicago, Los Angeles, Cleveland, Washington D. C. and Atlanta all scored below the Large Central City average at a statistically significant level. TUDA data is worth reviewing as black and/or Hispanic students comprise the majority of students in eighth grade in TUDA schools. Except for Austin, Charlotte and San Diego, TUDA schools have a higher percentage of students eligible for free or reduced-price school lunch than schools in Large Central Cities (Rampey, et al, 2005).

According to NAEP 2005 data, the average United States score in mathematics achievement (279) is below Proficient (299). NAEP 2005 data indicate that mathematics achievement of white students is significantly higher than that of black or Hispanic students. Mathematics achievement data also indicate that students who do not qualify for free or reduced-price lunch score significantly higher than students who do qualify. Students' mathematics achievement scores increase as their parents' level of education increases, also at a statistically significant level. The Trial Urban District Assessment (TUDA) data involve schools in urban areas that serve more than the average number of black, Hispanic and lower socioeconomic students. All but two school districts (Austin and Charlotte) score below the national average in mathematics achievement. One can consider TUDA data, reflecting urban schools that are primarily composed of black, Hispanic and low socioeconomic students, a litmus test on success in the United States in increasing mathematics achievement among low socioeconomic status and black and Hispanic students.

The NAEP 2005 results are consistent with the TIMSS 2003 results. Mathematics achievement among blacks and Hispanics and lower socioeconomic status students is lower than mathematics achievement among white students and those of higher socioeconomic status at a statistically significant level.

The achievement of students from the United States, as measured by The International Mathematics and Science Study (TIMSS) 2003, is below that of many industrialized nations with which the United States competes in the global and technological market. Scores of United States students reflect low mathematics achievement reflected disproportionately among students who are eligible for free or reduced-price lunches, among black and Hispanic students and among students whose parents have less education. Mathematics achievement of United States students reflected in the NAEP 2005 confirms the same patterns in low mathematics achievement reflected in TIMSS 2003. Additionally, NAEP indicates a positive relationship between mathematics achievement and the level of parent education. Finally, students who attending schools in the eleven urban school districts participating in the Trial Urban District Assessment of the NAEP (districts populated primarily by students qualifying for free or reduced-price school lunch, black and Hispanic students and students whose parents have less education than most United States parents) also reflect lower mathematics achievement than most United States students at a statistically significant level.

Mathematics and the Globalization of Technology and the Economy

The United States Department of Labor projects that the greatest industry growth from 2004 – 2014 will be in Education (32.5 percent), Health Services (30.3 percent) and Professional and Business Services (27.8 percent).³ Each of these industries reflects a growing dependence on technology and mathematics in its activities. Between 1983 and 1993, employment growth took place in jobs such as computer engineers, scientists and systems analysts (Rosenthal, 1995; Brauer, Hickock, 1995). In manufacturing, the transition to labor-saving technology including computer-operated processes and robotics has increased the demand for mathematics skills to manage the technology of the new manufacturing processes (Berman, Bound, and Griliches, 1994; Rosenthal, 1995; Borjas, 1995; Brauer, Hickock, 1995).

The United States exports goods that require skilled labor, often in technology-related fields, increasing the demand for skilled labor (Berman, et. al, 1994; Rosenthal, 1995; Borjas, 1995; Brauer, Hickock, 1995). Innovations in electronics, physics and pharmaceuticals - all math and/or technology related industries - have increased in volume in international trade (Montobbio, Rampa, 2005). Countries demonstrating a high degree of innovativeness and technology in their trade include China, Malaysia, Singapore and Thailand, with China and Singapore making great strides in technological competitiveness in the export market (Montobbio, Rampa, 2005).

The evidence for the effect of the globalization of the economy is well documented. The studies cited comprehensively reviewed data on trade, labor and patent approval to come to their conclusions. The United States exports goods requiring skilled labor. As a result, the United States requires more laborers who are skilled in technology

³ <http://www.bls.gov/iag/iaghome.htm>

and able to run the technology on which many manufacturing processes are increasingly dependent. Of the countries emerging as strong exporters of technology-based products, Singapore, Korea and China are outperforming the United States in the TIMSS, evidencing the development of a global mathematics-skilled workforce with which the United States must be competitive.

That the United States is losing its competitive edge due to low mathematics achievement is one concern that resulted in the recent introduction of H. R. 4734, the 21st Century National Defense Education Act. The purpose of the Act:

“To establish a comprehensive educational program to bolster the economic competitiveness and national security of the United States by promoting science, technology, engineering and mathematics education, careers, and capacity...”⁴

H. R. 4734 acknowledges that the United States is losing its innovative edge and that the consequences to the United States economy will be significant if this is not corrected.

Mathematics and Employability

As cited in the preceding section, recent growth in the labor market is concentrated in industries and occupations requiring skills in technology and mathematics. Many of these professions require at least 50 percent of their workforce to hold bachelor’s degrees and include employment in computer-related, medical, financial securities and science-related professions (Dohm, Wyatt, 2002; Moncarz, Reaser, 2002; Cuzzo, 2002). Significant areas of job growth also include specialty occupations, with computer engineers, scientists and systems analysts reflecting strong growth (Rosenthal, 1995; Moncarz, Reaser, 2002).

⁴ 21st Century National Defense Education Act, H. R. 4734, 109th Cong. § 2 (2006).

A direct relationship has formed between skills in mathematics and employment in today's economy as reflected in relationship between skills in mathematics and wage-earning power. Using the National Longitudinal Study of the Class of 1972 (NLS72), Altonji (1995) determined that one year of high school mathematics raises wages by 1.9 percent, which is a significant impact when put in the context of the resulting 7 percent increase resulting from one full year of postsecondary education. Murnane, Willet and Levy (1995) also used NLS72 data and High School and Beyond (HSB) data to study the relationship between basic cognitive skills and wages. Murnane et al. (1995) found that mathematics skills had a greater impact on wages for 1980 high school graduates than for 1972 graduates.

The research in this area is strong and consistent, with research from many sources reflecting a thorough and careful review of data and coming independently to the same conclusions. Industries are transferring from unskilled to skilled labor as they use technology for many systems once managed by individuals. Mathematics and technology are being applied to a wider range of functions within the areas of science, medicine, finance and other fields and occupations. A growing number of occupations require skills in mathematics and/or a bachelor's degree. Those with proven skills in mathematics will find greater employment opportunities and will find that wages reflect the value placed on skills in mathematics.

For those students who exhibit lower achievement in mathematics, the consequences in terms of employability and the ability to earn reasonable wages are negative and significant. As the economy becomes more dependent on technology to replace labor and to accomplish work more efficiently, mathematics and technology skills

in the labor force are becoming more necessary. Industries that depend on technology, such as engineering and the health professions, are on the rise.

Mathematics and College Access

As cited in the preceding section, a number of the evolving professions in the United States economy require greater mathematics skills and/or a college education. Access to college is a critical component of one's ability to prepare to participate meaningfully in the economy of today and of the future. Further, economic access is an urgent issue for poor people and people of color and this access is dependent on mathematics and science literacy (Moses and Cobb, 2001). Moses considers education a civil rights issue and has devoted his efforts in the Algebra Project, Inc. to working toward strong mathematics education for poor and minority students. Research on the value of mathematics education on access to and success in completing a bachelor's degree suggests that mathematics, often considered the "gatekeeper" curriculum in junior high and high school, influences access to a four-year college and one's ability to persist to graduation with a bachelor's degree.

Enrollment in eighth-grade mathematics is strongly associated with taking advanced mathematics in high school which, in turn, is strongly associated with enrollment in college (Choy, Horn, Nuñez, and Chen, 2000). Over 60 percent of students who enrolled in advanced mathematics in high school enrolled in a four-year college within two years of graduation (Choy, et al., 2000; Horn, 1997). In their review of the National Longitudinal Study of 1972 (NLS72) and High School and Beyond (HSB) data, Murnane, Willet and Levy (1995) found similar results and determined that the average

math score of those who went on to college was twice that of students who only completed high school.

Horn (1997), found that 64 percent of the at risk⁵ students she studied who enrolled in a four-year college had completed at least one advanced mathematics (algebra 3, calculus, trigonometry, analytical geometry) course. The percent of enrollment in a four-year college was lower for students who did not enroll in advanced mathematics, with 44 percent of those enrolling in mid-level math (algebra 2), 16 percent of those students who enrolled in only algebra and geometry and 6 percent of those students who took courses at a lower level than algebra and geometry enrolling in four-year colleges (Choy, et al., 2000).

Students who enroll in advanced mathematics courses in high school, regardless of their parents' education or socioeconomic status, will be more likely to enroll in a four-year college (Horn, Nuñez, 2000) and are more likely to persist to completion of a bachelor's degree (Adelman, 1999, 2006). Bachelor's degree attainment is significantly more likely for those students who have completed at least algebra 2 (Adelman, 1999, 2006). Adelman (1999, 2006) also found that the positive effects of enrollment in each more rigorous level of mathematics outpace the impact of lower socioeconomic status of students in predicting their likelihood of successfully completing a bachelor's degree.

Generally, colleges require three years of high school mathematics, including algebra 1, algebra 2 and geometry or calculus (Horn, 1997) to qualify for admission. Low-income, black and Latino high school graduates are less likely to meet these qualifications (Berkner, Chavez, 1997). A study of the transcripts of 16,000 2003

⁵ Single parent, change school more than two times, C or lower between 6th and 8th grade, low SES, repeated earlier grades

California high school graduates revealed that of African American students, 18.6 percent were eligible for admission to California State University and 6.2 percent were eligible for admission to the University of California; among Latinos the percent eligible were 16 percent and 6.5 percent respectively and among whites the percent eligible were 34.3 percent and 16.2 percent respectively (California Postsecondary Education Commission, 2004).

The research cited above is strong with all but the research on admission to California schools using comprehensive and representative data from National Longitudinal Study of 1972 (NLS72) and High School and Beyond (HSB). This research illustrates the value of participation in strong mathematics curriculum in eighth grade through high school to increase one's chances of enrolling in and graduating from a four-year college. Given today's economy and its dependence on mathematics skills to support technology, access to college is critical to all who intend to participate meaningfully in the economic life of the United States.

Supporting these findings, S. 2337, the College Pathway Act was recently proposed in Congress. The College Pathway Act attempts to address some of the concerns identified above and is designed to increase access to postsecondary education.

The bill states:

“Congress finds: Postsecondary education is an important aspiration for most students and the future strength of the United States economy and workforce largely depend on postsecondary attainments of all people of the United States, regardless of sex, race, or ethnic background.”⁶

The bill seeks to address a number of issues with particular attention to their effect on low-income and minority kindergarten through high school students. Among the issues

⁶ College Pathway Act, S. 2337, 109th Cong. § 2 (2006).

cited: ensuring that junior highs and high schools provide curricula of the quality and intensity necessary to ensure that high school graduates are prepared to enroll in four-year colleges without enrolling in developmental coursework as part of their college curriculum. The bill pays special attention to the curricula in mathematics, science and engineering.

Education in important mathematics in high school is becoming more necessary to ensure admission to college. With the need for a college education in order to equip one to make a living in today's economy becoming more critical, the importance of strong junior high and high school mathematics education increases. Students who take algebra in junior high and move to calculus in high school are the best equipped for college access. As the TIMSS 2003 and NAEP 2005 results indicate, students who are black, Hispanic and/or qualify for free or reduced-price school lunches are not receiving the junior high mathematics education necessary to set them on a mathematics trajectory that will equip them for employment in today's economy and that will provide access to college.

Principles and Standards for School Mathematics

In recent years, the National Council of Teachers of Mathematics (NCTM) has developed sets of standards intended to strengthen and standardize the quality of mathematics education in the United States and to ensure that all students, regardless of race, ethnicity or socioeconomic status, receive a high quality mathematics education that prepares them for participation in today's economy. In their introductory remarks, the authors refer to the importance of mathematics skills in today's economy and the

necessity of ensuring that mathematics achievement is evenly distributed among all populations.

The most recent set of standards published by the NCTM is Principles and Standards for School Mathematics (2000). A theme throughout the standards is that students should learn mathematics *with understanding*⁷. The Standards include five principles: Equity, Curriculum, Teaching, Learning, Assessment and Technology; and ten content standards: Numbers & Operations, Algebra, Geometry, Measurement, Data Analysis & Probability, Problem Solving, Reasoning & Proof, Communication, Connections and Representation. These principles and standards hold value for the quality of mathematics education and for working toward a consistent educational experience for students who move often and will transfer from one school to another. The Principles and Standards for School Mathematics (2000) provide basic principles to guide mathematics education policy and standards that guide mathematics curriculum decisions.

The NCTM Principles and Standards for Mathematics is provided to support efforts to ensure equity in education, that all students receive a strong mathematics education and to ensure that mathematics curriculum for all students is taught so that students learn with understanding and so that students learn the important mathematics that will prepare them for college access and enrollment and, ultimately, for productive employment.

A significant portion of the research review that follows will focus on the impact of application of the NCTM principles and standards on the equal distribution of

⁷ Italics added

mathematics achievement among minority students and students of lower socioeconomic levels.

Chapter Two: A Review of Research

This chapter will identify what is known about the pattern of lower mathematics achievement by lower socioeconomic and black and Hispanic students. A number of researchers have explored various hypotheses in their effort to identify causes for lower mathematics achievement in these population groups. The first body of research to be explored is research in the area of tracking.

Mathematics Achievement and Tracking

Tracking is the practice of sorting students into groups so that they can be assigned to classes of different levels of difficulty. The original intent of tracking, placing students into homogeneous academic groups, was to meet students' needs better in the academic setting and to reduce the range of material to be covered in a given class. Other reasons cited for grouping students by academic ability include the belief that more academically able students will learn more when they are grouped with similar students and the belief that less academically able students' self esteem will be protected if they are not placed in classes with more academically able students (Oakes, 1985). Oakes' research in this area is seminal and is the starting point for most research in tracking. Oakes collaborated on research of educational practice in twenty-five secondary schools that was very thorough in its investigation of each school including interviews with students, teachers, parents, principals, community members and school board members; review of school documents and observations of classrooms (Oakes, 1985). One finding of this study was the prevalence of the practice of tracking. What concerned Oakes about the practice of tracking was that, given the racial breakdown of each racially mixed school, a disproportionate number of poor and minority students were assigned to

vocational mathematics courses and a disproportionate number of white and higher socioeconomic status students were assigned to academic mathematics courses. Oakes' concern in her findings was that the practice of tracking resulted in lower socioeconomic status and black and Hispanic students having a lesser opportunity to learn, based on the content of their classes, than higher socioeconomic status and white students. In her continued research, Oakes reviewed tracking practices in 1200 schools and again found that lower track classes were disproportionately populated by lower socioeconomic status and black and Hispanic students (Oakes, 1990).

A statistically significant relationship exists between the level of parents' education and the level of mathematics course in which a student is placed (Dauber, Alexander, Entwisle, 1996; Useem, 1992). High school students from school districts of higher socioeconomic status (primarily white) are statistically more likely to be enrolled in calculus classes than high school students in school districts serving lower socioeconomic (primarily African American and Hispanic) students (Spade, Columba, and Vanfossen, 1997). Schools with a record of higher mathematics achievement for their students offer more advanced and college-preparatory mathematics courses than schools with a record of lower achievement, regardless of socioeconomic status of students attending the school (Useem, 1992; Spade, et al., 1997). Schools with a record of higher mathematics achievement, regardless of socioeconomic class of students, and schools serving higher socioeconomic students offer fewer remedial and lower track mathematics classes (Spade, et al., 1997). Schools serving lower socioeconomic students are less successful in encouraging students to enroll in advanced mathematics because they more often defer course choice to the student and their family whereas schools

serving higher socioeconomic students are more likely to include teachers and counselors in the course selection process (Useem, 1992; Spade, et al., 1997).

A three-year longitudinal study reviewed the experience of ten racially-mixed secondary schools in their implementation of a policy to detrack through student choice of courses (Yonezawa, Wells, Sema, 2002). Student choice was not found to be an effective detracking method as it failed to address the cultural norms surrounding the tracking experience. Obstacles to detracking included the following: 1) Institutional barriers including uneven distribution of information more effectively received by higher than lower socioeconomic status groups and lack of cooperation by academic counselors when lower track students opted to enroll in a higher track; 2) Lowered aspirations of students who had enrolled in lower track classes throughout their academic career and did not have the confidence to enroll in a more challenging academic course; and 3) Minority students expressed apprehension about enrolling in courses of primarily white students where they may not be treated with respect (Yonezawa, et al., 2002). The findings of this research are consistent with the conclusions of Oakes (1992) who asserts that changes in tracking must address three dimensions of the practice. The first of these is the technical dimension, or the revision of the curriculum. The second dimension of tracking to be considered by policy makers is the normative dimension as various communities consider tracking as a norm. Finally, Oakes discusses the third dimension that policy makers need to consider, the political dimension. A position of power often rest with those who are white and of a higher socioeconomic level, a condition affecting policy change in tracking.

Studies by Useem, (1992) and Spade, et al. (1997) are well done, using large samples that are carefully and thoroughly researched. Work by Dauber, et al. (1996) is less useful as the original population of 792, for the longitudinal study diminished to 212 by the time the students reached eighth grade. The study by Yonezawa, Wells, and Sema, (2002) was a three-year longitudinal study of ten racially-mixed schools with a thorough review of each. Unfortunately, the research by Yonezawa, et al. (2002) is almost entirely qualitative and provides no data on the number of students who were in lower tracks who did and did not enroll in higher track courses.

What we know from research in tracking is that black and Hispanic students as well as lower socioeconomic students are disproportionately enrolled in lower track mathematics courses. Students' enrollment in advanced mathematics courses increases with their parents' level of education. Tracking research also finds that the number of advanced mathematics courses available to students increases with the socioeconomic level of the students served. Regardless of the socioeconomic status of the students served, schools with a higher achievement level offer a greater number of advanced mathematics courses.

Although tracking researchers make reference to the negative academic consequences of enrolling lower socioeconomic status and black and Hispanic students in lower academic track classes, setting a trajectory that will not result in college-preparatory mathematics in high school; they do not explore in depth the methods for assigning students to their particular tracks. There is an underlying assumption, which is not tested, in tracking research that the assignment of lower socioeconomic status and

black and Hispanic students to lower track mathematics classes is arbitrary and reflects a bias against these population groups.

Mathematics Achievement and Curriculum

Research on the mathematics curriculum and its influence on the mathematics achievement of students of lower and higher socioeconomic status builds on tracking research. Tracking research suggests that opportunities to learn are not fairly distributed but does not identify a causal link between track placement and mathematics achievement. Curriculum research picks up where tracking research leaves off and explores the impact of the participation in/enrollment in lower and higher level mathematics classes on student achievement.

Many researching curriculum test the hypotheses that students of all abilities will benefit from access to curriculum teaching important mathematics and that teaching mathematics in heterogeneous classes will not have a negative affect on any ability group. Also explored is the hypothesis that a common curriculum, in which all students are taught the same content, enrolling some in “stretch courses” covering the curriculum two terms rather than one, is preferable over a tracked curriculum which serves as a mathematics filter rather than a pump. Students assigned to low level mathematics courses in eighth grade or earlier may be set on a trajectory (filter) that will make college preparatory mathematics unlikely or impossible regardless of their ability or potential.

Curriculum and tracking research fairly uniformly suggest that schools serving upper socioeconomic and white students offer more classes in advanced mathematics such as calculus, trigonometry and AP mathematics (Lee, Croninger, Smith, 1997; Spade, Columba, Vanfossen, 1997). Independent of the socioeconomic status of the students

served, schools with higher achievement levels offer more advanced mathematics classes (Spade, et al., 1997; Lee, 1997).

A number of researchers have studied the value of taking algebra, the first of the mathematics classes considered important math and the first step in the trajectory leading to college- preparatory mathematics. Gamoran and Hannigan (2000) found that students of a wide range of math abilities who took algebra whether in eighth, ninth or tenth grade, demonstrated achievement growth at a significant level unless they were in the lowest twentieth percentile. Even among students in the lowest twentieth percentile, benefits were found, although not at a significant level. High school students who enrolled in algebra demonstrated a significantly greater growth in mathematics achievement than students enrolled in general-track mathematics classes with a less challenging curriculum (Gamoran, Porter, Smithson, and White, 1997) Students who enroll in algebra in eighth grade are more likely to complete advanced-level mathematics in high school (Horn, and Nuñez, 2000). Choy, Horn, Nuñez and Chen (2000) found, similarly, that students who took mathematics classes in eighth grade were more likely to take advanced mathematics in high school and were, in turn, more likely to enroll in a four year-college.

Students whose parents have not attended college are less likely to attend schools offering algebra, Choy, et al. (2000). Among students with strong mathematics proficiency, 70 percent of those whose parents attended college were strongly encouraged to take algebra compared to 52 percent of those whose parents had not attended college (Choy, et al., 2000). Gamoran and Hannigan (2000) found that students who did not take algebra had the lowest mathematics test scores in eighth and tenth grade and that this

group consisted of students of the lowest socioeconomic level and were disproportionately African American and Latino at a significant level.

Regardless of academic history, students participating in the following academic experiences will exhibit a higher level of academic achievement than students not exposed to these circumstances: enrollment in rigorous curriculum including math lab for students who do poorly in state exams, summer mathematics for students who want to catch up or double up to stay on the college-preparatory trajectory, completing a minimum of three high school mathematics classes and participation in a common/constrained curriculum with few lower level courses (Gutiérrez, 1996, 1999, 2000; Carbonaro, 2005).

Exploring the impact on academic trajectory of enrollment in different levels of mathematics classes in ninth grade, White, Gamoran, Smithson and Porter, (1996) found that only 14.8 percent of students enrolled in general mathematics, 49.8 percent of students enrolled in transition mathematics (designed to replace general math) and 87.7 percent of students who began their enrollment in a college-preparatory track ultimately completed the college-preparatory curriculum during their high school career.

Rose, (2004) found a positive relationship between increased enrollment in algebra and geometry and higher achievement in mathematics that would lead to narrowing the gap between black and Hispanic students and white students

In their research on the impact of the introduction of calculus into the curriculum of an inner-city high school that had lost its accreditation, Werkema and Case, (2005) found that students in a school serving primarily lower socioeconomic and black and Hispanic students enrolled in rigorous mathematics courses and experienced academic

success and mathematics achievement that would not have been expected in their environment.

The research cited in this section is strong. Research by Horn and Nuñez, (2000); Gamoran and Hannigan, (2000) and Choy, et al. (2004) each used the National Education Longitudinal Study of 1988 (NELS:88) data and thorough investigative techniques to obtain and analyze their data. Lee, et al. (1997) used data from the 1990 (The National Assessment of Educational Progress) NAEP for 3,056 seniors from 123 public high schools that were carefully selected to represent broad demographics. Rose, 2004 used NELS:88 and The High School and Beyond (HSB) 1980 – 1992 data in her research of mathematics achievement scores and transcript relationships for black and Hispanics. Gamoran, et al. (1997) used a sample of 882 students from 48 classes attending 7 carefully selected high schools. Werkema and Case, (2005) used one inner city high school for an in-depth case study. Gutiérrez, (1996, 1999, 2000) invested a number of years in her study of eight high schools serving primarily black and Hispanic, urban and low socioeconomic students. Her data collection was comprehensive, including mathematics achievement data, school curriculum documents and policy statements, on-site visits and interviews of a large range of those involved in the educational process. In all these studies, the sample included black, Hispanic and white students and students of low and high socioeconomic status to allow for testing of hypotheses on differences in achievement between these populations.

The research on curriculum has produced helpful information in understanding differences in mathematics achievement between low and high socioeconomic students. This research suggests that students of varying mathematics abilities will learn more and

achieve more when exposed to more challenging mathematics curricula, or what is often considered important math. Research on curriculum provides data that indicate that differences in mathematics achievement between white and black and Hispanic and between lower and higher socioeconomic students can be traced to enrollment or non-enrollment of each population in courses teaching important mathematics. This research supports the point of view that enrollment in important mathematics curricula can, irrespective of the academic history of students, serve as a pump that moves students into the advanced high school mathematics and into higher mathematics achievement.

Mathematics Achievement and Access to Educational Resources

The research on the role of access to educational resources and their relationship to differences in achievement between black and Hispanic and white students and between low and high socioeconomic students is fairly broad. Some researchers have hypothesized a causal link between financial resources or inputs, however they are invested, and student achievement in mathematics. Other studies hypothesize that students who have teachers who are “qualified” (having a major or minor in mathematics) to teach mathematics will have higher mathematics achievement. Researchers also hypothesize that lower socioeconomic students achieve less in mathematics because they do not have access to the resources at home and at school (cultural capital) to which students at higher socioeconomic levels have access. The difficulty with some of the research in this area is the clear definition of an independent variable so that a causal relationship between the independent variable (resource) and dependent variable (math achievement) can be measured.

The first area to review is the exploration of the relationship between financial resources and student achievement. Although not specifically related to mathematics achievement, two pieces of seminal research by Hanushek, (1997) and Greenwald, Hedges and Laine, (1996) merit review. Hanushek (1997) conducted a meta-analysis of 400 studies of the relationship between school finance inputs and student achievement. Hanushek, (1997) found no strong relationship between the two. Greenwald, et al., (1996) conducted a meta-analysis of 60 primary research studies on school finance inputs and student achievement. Greenwald, et al. (1996) came to the opposite conclusion, determining that their data suggests that a broad range of resources are positively related to student outcomes enough to recommend moderate increases in spending on school inputs. To sort through the opposing conclusions of Hanushek, (1997) and Greenwald, et al. (1996), Elliott, (1998) developed a research model designed to track funds more directly to student achievement in mathematics. Investigating the connection between United States Census data and NELS:88 student achievement data, she concluded that funds as measured by per pupil expenditures (PPE) do positively affect student achievement in mathematics because these funds are spent on hiring and training of qualified teachers and on equipment such as computers and calculators. Elliott's research has a couple of difficulties in that all of the teachers in her study had fifteen years of teaching experience and were certified to teach mathematics, not a random sample. Elliot does not specifically test her assertions that money spent on teachers or that money spent on equipment directly impacts student achievement.

A second set of studies finds a positive relationship between parent education and the likelihood that students will have a teacher who has either a major or minor in

mathematics and who teaches for understanding (Raudenbush, Fotiu, Cheong, 1998; Ingersoll, 1999). In New York, urban schools and schools serving low-income, low-achieving and non-white students employ less qualified mathematics teachers (Lankford, Loeb, Wyckoff, 2002). One third of all secondary school teachers in mathematics have neither a major nor a minor in mathematics; the same research also determined that for high-track mathematics classes studied, 20.4 percent are taught by unqualified teachers compared with 33.5 percent of low track mathematics classes (Ingersoll, 1999).

Examination of the relationship between six levels of mathematics teacher qualification and the mathematics achievement of low-income Hispanic sixth- through eighth-grade students found no relationship between the qualifications of the mathematics teachers and the mathematics achievement of their students (Reyes, 2003). Reyes found evidence that alternative certification and permit teachers were more successful in teaching mathematics, possibly related to their use of what she judged as a more culturally responsive pedagogy.

In research exploring the relationship between cultural capital (e.g., number of books at home, cultural trips), a relationship was found between cultural capital and a student's socioeconomic status; however, this did not translate into a relationship between cultural capital and mathematics achievement (Rosignano, Ainsworth-Darnell, 1999). Rosignano, (1998) also explored the hypothesis that teachers' awareness of the lower cultural capital of lower socioeconomic students would result in lower mathematics track placement and did not find support for this hypothesis. Rosignano, (1998) did find a positive relationship with cultural capital as defined by one's peers and mathematics achievement.

Research on the relationship between resources and mathematics achievement has not produced conclusive results. Exploration of the relationship between financial inputs and mathematics achievement, even when thoroughly and carefully conducted with large data sets, arrives at conflicting results as with Hanushek, (1997) and Greenwald, et al. (1996). Elliott's (1998) efforts to sort through the disparity in findings did not produce helpful results as the causal relationship she worked to construct between finances and mathematics achievement was not clear or convincing. Research on teachers is varied and stems from the hypothesis that having qualified teachers (having a major or minor in mathematics) leads to mathematics achievement. Raudenbush, et al. (1998) use a sample of almost 90,000 eighth graders sampled randomly to ensure representation for urbanicity, minority and socioeconomic ranges and measures mathematics achievement through the 1992 State NAEP. Raudenbush's research on the relationship between teachers and student population groups is strong, but summary comments reflect on the difficulty of using state by state data when the variance of data within each state is wide and not entirely represented in their data. Research by Lankford, et al. (2002) is poorly done with data variables that are not defended or weighted to give them the clarity of definition or credibility they need to serve as an independent variable. Work by Ingersoll, (1999) on out-of-field teaching is carefully done, but Ingersoll cautions that out-of-field teaching cannot simply be attributed to the economics or teaching challenges due to poverty of students of a particular school district. Reyes, (2003) does not find a relationship between teacher qualifications and student mathematics achievement, but recommends research to explore the impact of bilingual teachers and the impact of

culturally sensitive pedagogy for Hispanic students. While Reyes' research was carefully done, the sample is too small to allow generalization to a larger population.

Mathematics Achievement and Student Effort

Explored in this body of research is the hypothesis that students of color and students of lower socioeconomic status achieve less in mathematics because they do not invest effort in learning as they are antagonistic toward the goals of learning espoused by a culturally and personally oppressive environment. Ogbu and Simmons' (1998) research serves as a starting point for some work in this area. Ogbu proposed the theory of involuntary minorities (Ogbu and Simons, 1998). Ogbu attributed poor performance by involuntary minority students (primarily black students) to their response to a history of denial of educational, employment and other opportunities expressing itself in a lack of hope and lack of investment in the educational process.

Although the research in this area is fairly limited, it is important to include as it speaks to the other end of the "responsibility for learning continuum" (student or educational system).

Explored in this research is the concept of engagement, defined as showing up for class, doing what the teacher directs the students to do, doing homework, having a positive attitude about the value of education and being optimistic about one's employment future resulting from completing an education. In these measures of engagement, researchers found that black and white students demonstrate equal engagement (Ainsworth-Darnell, Downey, 1998; Smerdon, 1999). Ainsworth-Darnell, et al. (1998) found that the relationship between positive attitude and grades is higher for

whites. Smerdon, (1999) found the relationship between engagement and achievement to be weak. Carbonaro, (2005) found little or no relationship between race and effort but found, instead, a positive relationship between academic stimulation and effort for blacks and whites. Ainsworth-Darnell, et al. (1998), testing the hypothesis that black students would be penalized by their peers for achieving well and “acting white”, found that black students who are perceived as good students are popular among their peers. Ainsworth-Darnell, et al. (1998) found that black students are significantly more positive about the importance of their education and significantly more optimistic in their occupational expectations than are white students.

Ainsworth-Darnell, et al. (1998), Smerdon, (1999) and Carbonaro, (2005) used NELS:88 data and large representative samples to test their hypotheses. The research in all three cases was well done. This research does not find a relationship between lower student effort due to lack of engagement with the educational process on the part of blacks and mathematics achievement.

Mathematics Achievement and Teacher Professional Community

Not surprisingly, there is a plethora of research trying to identify a causal relationship between teachers and mathematics achievement. The underlying question to be addressed is the level of responsibility for learning that can be attributed to teachers. The extent to which the teacher is responsible for learning will impact the way teachers are supervised, organized and rewarded and the level of collaboration between teachers.

A number of teacher behaviors are associated with higher mathematics achievement that is equitably distributed to include lower socioeconomic, black and

Hispanic students. One teacher behavior with a significant relationship to higher mathematics achievement is teacher availability outside of the classroom and outside-of-class time for formal and informal tutoring (Gutiérrez, 1999, 2000). Creativity in teaching is also associated with higher mathematics achievement for students considered high-risk (poor and minority). Included in the pedagogy of creative teaching is the use of group work rather than a reliance on lectures and seat work, the use of computers and calculators in teaching, and the use of additional materials in addition to good text books as teaching aids (Gutiérrez, 1996, 2000). Teachers who are effective in creating a learning environment that equitably produces learning take an active role in the learning process, are less influenced by academic history, and take greater responsibility for influencing student motivation to learn (Gutiérrez, 1996). Teachers who create this mathematics learning environment are typically part of a collaborative association of teachers who share information about their teaching strategies, share information about their students and who rotate teaching assignments rather than developing a pecking order of the best course to teach (Gutiérrez, 1996, 1999, 2000; Lee, Smith, 1996).

Although there is not a significant amount of research in this area, what is available is strong and convincing. Research by Gutiérrez, (1996, 1999, 2000), based on high-risk student groups in eight high schools, is deep, both qualitative and quantitative, and carefully done. Lee and Smith, (1996) relied on a large sample from the NELS:88 focused on mathematics achievement as it affects minority and lower socioeconomic students. Research in this area concludes that considerable responsibility for learning, even for learning among students who are considered high risk, lies with the teacher and the educational environment.

Mathematics Achievement and Culturally Responsive Pedagogy

In the review of research on resources and mathematics achievement, Reyes (2003) recommended that future research explore the relationship between culturally responsive pedagogy and mathematics achievement of low income Hispanic students. As noted in the section above reviewing research on teacher community and mathematics achievement, Gutiérrez (1996, 1999, 2000) and Lee and Smith (1996) each note a relationship between particular teaching pedagogies and higher mathematics achievement among low income, black and Hispanic students. Including in these teaching pedagogies were more creative course content and availability of mathematics teachers to students outside of the formal classroom setting.

Smith-Maddox (1998) examined the effect of selected dimensions of culture on the mathematics achievement of eighth graders. Smith-Maddox examined student characteristics, family characteristics, school characteristics and teacher perceptions. Smith-Maddox used Base Year data for the National Educational Longitudinal Survey of 1988 (NELS:88). For student demographics, Smith-Maddox used NELS:88 data on race, gender, educational aspirations, homework habits, activities, Cultural Synchronization and Culturally Relevant Content. For family characteristics information, the NELS:88 data used included socioeconomic status, parental involvement and parent's educational expectations. School characteristics included percentage of minority students attending each school. Data on teacher perceptions included the teacher's assessment of the student's placement in an achievement-level group. Smith-Maddox found that the factors most related to student achievement were the students' aspirations and homework habits,

parent's socioeconomic status, parent involvement and communication with teachers. Factors having a negative affect on achievement included the percentage of minorities enrolled in the student's school. Relative to the effect of cultural measures on student achievement, Smith-Maddox found inconsistent results across different racial lines and ethnic groups with the weakest relationship between cultural measures and student achievement among African American students. The results relative to the relationship of cultural measures and achievement were not significant.

Gloria Ladson-Billings' (1994, 1995a, 1995b) research on culturally sensitive pedagogy is seminal. Her research is thorough and in depth, making it foundational in nature and producing a basis for future research. Ladson-Billings conducted three years of careful qualitative research of teachers who were successful teachers of African American students resulting in the development of her theory of Culturally Relevant Pedagogy. Within a small, primarily African-American, low-income elementary school district, Ladson-Billings surveyed parents and principals to identify eight teachers considered successful teachers of the district's children. Of these eight, seven participated in Ladson-Billings' three-year study which was conducted in four phases. In phase one, Ladson-Billings conducted ethnographic interviews of the teachers to gain an understanding of the background and teaching philosophy, their ideas about curriculum, classroom management, parents and community involvement. In phase two, Ladson-Billings made unannounced visits to observe the teachers in their classrooms three times a week for two years. Ladson-Billings took field notes and audio-taped classes and discussed them with teachers afterward. In phase three, Ladson-Billings videotaped the teachers in class. In phase four, Ladson-Billings held ten meetings with

the teachers that lasted for two hours each and included viewing, analysis and discussion of the videotapes.

What emerged from this research is Ladson-Billings' (1994, 1995a, 1995b) theory of Culturally Relevant Pedagogy which she proposed would do three things: 1) produce students who can achieve academically, 2) produced students who demonstrate cultural competence and 3) develop students who can understand and critique the existing social order.

In her book The Dreamkeepers: Successful Teaching of African-American Children (1994), Ladson-Billings outlines the characteristics of Culturally Relevant Pedagogy:

Conceptions of Self and Others

- Teacher sees self as artist, teaching as an art
- Teacher sees herself as part of the community and teaching as giving back to the community, encourages students to do the same
- Teacher believes all students can succeed
- Teacher helps students make connections between their community, national and global identities
- Teacher sees teaching like “pulling knowledge out” – like “mining”

Social Relations

- Teacher-student relationship is fluid, humanely equitable, extends to interactions beyond the classroom and into the community
- Teacher demonstrates a connectedness with all students
- Teacher encourages a “community of learners”
- Teacher encourages students to learn collaboratively. Students are expected to tech each other and be responsible for each other

Conceptions of Knowledge

- Knowledge is continuously recreated, recycled and shared by teachers and students – it is not static or unchanging
- Knowledge is viewed critically
- Teacher is passionate about content
- Teacher helps students develop necessary skills
- Teachers sees excellence as a complex standard that may involve some postulates but takes student diversity and individual differences into account

Love and Kruger (2005) explored the work of Gloria Ladson-Billings (1994, 1995a, 1995b) and her theory of Culturally Relevant Pedagogy. Love and Kruger developed a questionnaire which tested teachers on their adherence to the model of Culturally Relevant Pedagogy that Ladson-Billings had developed. Love and Kruger then determined the relationship between the teacher's alignment with Culturally Relevant Pedagogy and the achievement of predominantly low-income African American students attending two urban elementary schools. Correlations between the teacher questionnaires and student achievement indicated some relationship between student achievement and teachers' beliefs supporting Culturally Relevant Pedagogy. The 48 statement questionnaire was organized into six categories rather than the three categories comprising Culturally Relevant Pedagogy. Of the 48 statements on the questionnaire, nine correlated with student achievement, one question measuring the teachers' Conceptions of Knowledge, four questions measuring the teachers' beliefs about Social Relations, one question related to teachers' beliefs about teaching as a profession, two questions identifying teachers' beliefs about teaching practice and one question on assessing teachers' beliefs about student's needs and strengths. Some statements reflecting Culturally Relevant Pedagogy did not correlate with student achievement.

The research on culturally sensitive pedagogy tests the hypothesis that differences in teaching pedagogy including more creative teaching styles and more varied curricula and a broader definition of the teacher-student relationship will result in higher achievement by low income African-American students. Results suggest that this perspective on mathematics achievement merits further exploration. Researchers recommended that a more in-depth look at differences in the effect of culturally sensitive

teaching pedagogy within the African-American student population be explored to test the hypothesis that within this community there are differences in which teaching pedagogies are most effective. This research is conducted on students from elementary school through eighth grade – high schools students are not included and need to be included in future research in this area. Additionally, the research cited focuses primarily on African-American students although both African-American and Hispanic students are known to struggle with low achievement. Research included Hispanic students is needed. Finally, this research is not specific to mathematics but is related to a full array of curricula. Given the pattern of low mathematics achievement by low income African-American and Hispanic students and given the “gatekeeper” function of high school mathematics to college access and employability, more research is needed on the effect of Culturally Relevant Pedagogy on mathematics achievement.

Summary

Researchers have attempted to identify the cause for differences in achievement in mathematics that are evidenced in both the TIMSS 2003 and NAEP 2005 – the lower mathematics achievement of students who are black, Hispanic and/or of a lower socioeconomic level. Many researchers investigate causes within the education system such as tracking, curriculum, access to educational resources, culturally sensitive pedagogy and teacher professional community. Others investigate whether the cause of lower mathematics achievement is the results of lower effort or lower engagement in education by those who achieve less.

The primary hypothesis explored in research on tracking is that, because lower socioeconomic and black and Hispanic students are disproportionately assigned to lower-level mathematics track classes, they learn less and achieve less. Research in tracking has not offered information helpful to understanding the differences in achievement between black and Hispanic and white students and between low and high socioeconomic students. Research on curriculum suggests that differences in achievement between black and Hispanic and white students and between lower and higher socioeconomic students is a result of the greater chances that white and higher socioeconomic students will attend schools with a constrained curriculum that enroll more of their students in a college-preparatory mathematics trajectory.

The relationship between access to resources and mathematics achievement is explored in three areas: 1) access to financial inputs; 2) access to qualified teachers; and 3) access to cultural capital. Studies exploring the relationship between financial inputs and mathematics achievement pursue the hypothesis that the greater the student's access to financial inputs, as measured by per pupil expenditures and other measures, the greater their mathematics achievement. Research produces conflicting and inconclusive results to this hypothesis. Research on teachers pursues the hypothesis that students who are taught by teachers who either majored or minored in mathematics in college will learn more than students who are taught by out-of-field teachers. The research does not support this hypothesis. Studies exploring the relationship between student access to cultural capital and its impact on mathematics achievement test the hypothesis that lower socioeconomic and black and Hispanic students have less access to cultural capital and

are academically handicapped by this and reflect lower achievement in mathematics as a result. The research results do not support this hypothesis.

Research on student effort tests the hypothesis that lower achievement among lower socioeconomic status and black and Hispanic students is a result of their unwillingness to invest effort in their education and their unwillingness to engage in the educational process. Results from research pursuing this hypothesis did not support the hypothesis. In summary comments, researchers expressed a goal of putting to rest the belief that students can be “blamed” for their academic failure, thus letting the education system off the hook.

Research on teacher communities pursues the hypothesis that when teachers teach as though they are primarily responsible for their students’ learning, their students will learn more. This sort of teacher community is characterized by collaboration among teachers where class assignments are rotated and information about students is shared; where teachers are available to students outside-of-class time for help and tutoring and where teachers use methods for teaching beyond lecture, seat work and sole reliance on text books. Research results in this area support the hypothesis.

The hypothesis explored in research on culturally sensitive teaching pedagogies is that a different teaching pedagogy, characterized by variation in curricular content and a different approach of teachers to their relationships with their students, may result in stronger achievement among African-American students, many of whom are also low income. Although this research concerns itself primarily with grade school African American students, the results suggest that teaching pedagogies that are culturally

sensitive have a positive effect on the academic achievement of African American students.

If one's intent is to understand the differences in mathematics achievement between black and Hispanic and white students and between lower and higher socioeconomic students with the intent of contributing further to research to provide data to inform policy to reduce these differences, this research provides a valuable foundation. Some of the more profound findings, in my opinion, suggest that regardless of their academic history or socioeconomic status, students who are enrolled in challenging mathematics curriculum will learn more. The responsibility for learning is more persuasively placed on the education system, reducing the basis to "blame" students for their low achievement. Some research suggests that what contributes to student achievement more than the qualifications of the mathematics teacher is their teaching pedagogy, their participation in a professional teacher community and the quality of the academic curriculum in which a student is enrolled.

Given the impact of mathematics skills on one's ability to make a living and to participate meaningfully in today's economy, it is critical that we make progress on efforts to ensure that achievement in mathematics is evenly distributed to all population groups in the United States. The research cited in this paper provides avenues for further research toward the goal of informing practice and policy in support of the goal of strong mathematics achievement for all students in the United States.

Chapter Three: Innovations to Address Low Mathematics Achievement by Low Income and Minority Students

There are a number of mathematics programs designed to increase the mathematics achievement of low income black and Hispanic students. Each of these programs is characterized by variety and creativity in teaching pedagogies, availability of teachers outside of classroom time and an expectation that the students enrolled in the classes will exhibit strong achievement in mathematics. The following are descriptions of the mathematics education programs of innovative educators experimenting with new pedagogies for mathematics education.

Jaime Escalante Math Program

Jaime Escalante has demonstrated significant success in his ability to educate low-income, urban and minority high school students in Los Angeles to high levels of achievement in advanced mathematics (Escalante and Dirmann, 1990). Using a number of innovative pedagogical tools, Escalante works to create an environment that inspires and supports high mathematics achievement of its students. Many of the principles espoused by Escalante are in line with research cited in the previous chapter.

Escalante emphasizes the importance of bringing a sense of fun and enjoyment of learning to the classroom. He uses sports analogies with his students, considering himself their coach and his students the team. He also capitalizes on the sports heroes that are meaningful to students, putting their posters on the wall of his classroom and drawing a parallel between the discipline necessary to be a highly successful athlete and the discipline necessary to be a highly successful mathematics student. Escalante tells his students that all they need to be successful in his classes is “ganas” or motivation.

Further, Escalante organizes his students into teams and gives them mathematics projects to work on together. Escalante works to ensure his students understand the value of mathematics and the sciences to their future. Escalante takes students on field trips to technology-based industries employing minorities so that they can see the value of mathematics in earning a good living and to give them role models. Also, to provide role models, Escalante invites his graduates to speak to his class about their career and college life and the value of mathematics in each.

Escalante immediately sets his students on the mathematics trajectory that ends in calculus in their senior year. If they have not taken algebra I when they arrive in high school, then his students take mathematics courses in the summer to ensure that they complete the necessary curriculum: algebra 1, geometry, algebra 2, trigonometry/math analysis, first year or second year calculus. Escalante does not place his students in mathematics tracks, but facilitates a constrained curriculum where all students are enrolled in advanced mathematics on a college-preparatory trajectory. Escalante requires his students to arrive for school early, to stay after for study sessions and to attend Saturday mathematics sessions. He makes himself available outside of classroom time to assist his students.

To recruit his students, Escalante works with staff at three feeder junior high schools that assist in identifying students with promise. He also works to engage parents in the educational process. Parents sign a contract committing to support their student and Escalante contacts them to enlist their help at the first sign of trouble.

As needed, Escalante has worked hard to obtain the financial resources necessary to teach math well. This has taken the form, primarily, of money spent on the best textbooks.

While most of the description of the success of Escalante's mathematics program is anecdotal, a measure of outcomes by AP test participation and scores provide concrete results. During the first twelve years of his tenure, the number of AP tests taken at his school increased from 10, with no calculus tests, to 450 AP tests administered in 16 different subjects. These changes in AP participation and scores suggest a significant change in Escalante's school as a result of his mathematics teaching pedagogy.

The Algebra Project

The Algebra Project was established by Bob Moses (Moses and Cobb, 2001). Moses, who was involved in voter registration in the South, believes that math is a civil rights issue and that mathematics literacy is a requirement for all students to ensure that they are able to participate fully in the economic life of their environment.

The centerpiece of the Algebra Project is its teaching pedagogy. Rather than treating mathematics as an abstract subject, the Algebra Project begins by making mathematics practical and easy to relate to. The Algebra Project offers training to teachers, helping them to unlearn current teaching practices and to replace those practices with ones more relevant to the urban poor on whom the Algebra Project focuses.

A central piece of the curriculum of the Algebra Project is the Transition Curriculum which assists students in their transition from arithmetic thinking to algebraic thinking. The Transition Curriculum has a five step process⁸

- 1) Participate in physical event – often a subway or bus ride or a walk
- 2) Make a graphic representation of the event
- 3) Discuss and write about the event in comfortable or intuitive language
- 4) Discuss and write about the event in structural language –moving to abstract
- 5) Develop symbols to represent the experience

One portion of the curriculum used to teach ratios is the African Drum and Ratios Curriculum. This curriculum draws on drum sounds and drum-making activities to teach concepts including ratio, proportion, multiples, numbers, patterns and area.

Relative to the research cited in this paper, The Algebra Project has developed a culturally sensitive pedagogy for teaching mathematics that is espoused to be effective with poor and minority students. Information on the Algebra project does not address assessment, AP testing or college access as indicators of successful outcomes of the program.

The Teaching Excellence for Minority Student Achievement in the Sciences

(TEMSAS) program is targeted at keeping African-American and Hispanic students in the educational pipeline to ensure their preparation to participate in a technology-driven economy. The instruction in TEMSAS, heavily focused on mathematics, is characterized by investigation and experimentation, with the use of participative activities such as games and music. Of the students who participated, 90% indicated an interest in a career

⁸ <http://www.algebra.org>

in mathematics or science and confidence to participate in mathematics and science curricula in their public school (Adenika-Morrow, 1995).

The Core-Plus Mathematics Project (CPMP) is a three-year high school mathematics curriculum program with its basis on recommendations included in the National Council of Teachers of Mathematics 1989 *Standards* document. The goal of CPMP is to promote access and equity in mathematics for all students and to promote achievement by African-American, Hispanic and other minority students not served well by existing mathematics curricula and pedagogy. CPMP emphasizes investigation and exploring both in groups and individually. The teacher serves as the facilitator and learning guide rather than the source of “the answer”. The nature of student participation that is encouraged in CPMP allows students to bring their culture into the classroom (Hirsch, Coxford, Fey, and Schoen, 1995; Hirsch, and Coxford, 1997).

The Summer Enrichment Program McShea and Yarnevich (1999) studied the effects of the National Society of Hispanic Masters of Business Administration (NSHMBA) Summer Enrichment Program on the PSAT and general achievement in high school mathematics scores of students participating in the program. Two thirds of the six-week program focused on a mathematics curriculum characterized by the use of manipulatives, cooperative learning and hands-on work with computers and work with calculator technology. The pedagogy was intended to create an environment of exploration and creative problem solving. Students who participated in the program did as well as or

better than a control group of Hispanic students who were placed in a college-bound mathematics program.

Summary

Over the past fifteen or so years, a number of educators have worked to develop mathematics teaching pedagogies that address the concerns and insights reviewed in previous chapters. They have worked to develop mathematics teaching pedagogies that move away from the lecture-style and solitary and competitive educational environment that characterizes many of today's mathematics classrooms toward an educational environment characterized by experimentation, discovery and collaborative work and the teacher as the facilitator of learning rather than the source of knowledge. The anecdotal descriptions of success in many of these programs are supported by the research reviewed in Chapter Two.

Chapter Four: Research Method

The goal of this research is to further explore the impact of Culturally Relevant Pedagogy on mathematics achievement. Taking as a basis Ladson-Billings' (1994, 1995a, 1995b) theory of Culturally Relevant Pedagogy and building on the work of Love and Kruger (2005), this study explores the impact of Culturally Relevant Pedagogy on the mathematics achievement of high school students.

Hypotheses

Of particular interest in this study is the effect of Culturally Relevant Pedagogy on the mathematics achievement of black and Hispanic high school students. Ladson-Billings' assertion that Culturally Relevant Pedagogy will produce students who can achieve academically (Ladson-Billings, 1994) serves to form the basis of the hypotheses. Will black and Hispanic students who are taught mathematics by teachers who practice a teaching pedagogy more in line with Culturally Relevant Pedagogy achieve more in mathematics than those black and Hispanic students whose teachers' pedagogy is not in line with Culturally Relevant Pedagogy? Based on the work of Ladson-Billings (1994, 1995a, 1995b), this research addresses the following hypotheses:

Hypothesis 1: Black students who are taught by mathematics teachers who utilize teaching practices in line with Culturally Relevant Pedagogy will achieve more in mathematics than black students whose teachers do not utilize teaching practices in line with Culturally Relevant Pedagogy.

Hypothesis 2: Hispanic students who are taught by mathematics teachers who utilize teaching practices in line with Culturally Relevant Pedagogy will achieve more in

mathematics than Hispanic students whose teachers do not utilize teaching practices in line with Culturally Relevant Pedagogy.

Data Set

NELS:88 Mathematics Achievement Data

The source of data for this study is the First Follow Up Year study of the National Educational Longitudinal Study of 1988 (NELS:88). To review, NELS:88 is a longitudinal study of 24,599 eighth graders attending 1,052 schools in the U.S. NELS:88 was created and financed by the National Center for Education Statistics (NCES) to collect data on students in their transition from junior high through high school (Curtain, Ingels, Wu, & Heuer, 2002). The survey was initiated in 1988 and the cohort of students was tested again in 1990 and 1992. Patterns of mathematics achievement found in the TIMSS 2003 and NAEP 2005 achievement tests are also reflected in the NELS:88 data.

The 1990 cohort of students is used for this research because this data set contains the full range of variables needed for this study. The sample consists of students for whom data are available from their mathematics teacher. As the focus of this study is to compare the mathematics achievement scores of two specific minority groups -- black and Hispanic students -- with those of white students, Asian Pacific Islanders and American Indian/Alaskan Native students were removed from the sample. The resulting sample of 6738 students allows the assessment of the teacher's level of Culturally Relevant Pedagogy as well as demographic and school variables and their affect on the student mathematics achievement.

Three different questionnaires provided data for the First Follow Up Year NELS:88 study. The first of these is the student questionnaire obtained from the NELS:88 sample. The student questionnaire covers areas including cognitive growth, school practices, school effectiveness, and parent and community involvement.

The second of these is an administrator questionnaire from the principal or his/her designee of the school attended by the sample student. The results of the administrator questionnaire are linked to the specific student. The school administrator questionnaire, a 60 minute self-administered questionnaire, includes the following areas: general school characteristics, general student characteristics, teaching staff characteristics, school admission policies and practices, grading and/or testing structure, program and facilities information and school cultural and behavioral climate.

The third questionnaire is the teacher questionnaire. The purpose of the teacher questionnaire is to gain information that can be used to analyze student outcomes. The teacher questionnaire provides information on: the teacher's assessment of the student's school-related behavior and academic performance, education and career; information about the class the teacher taught to the sampled student; information about the teacher's background and activities and information about the school climate and organization. For each student, two teachers completed a questionnaire. One of these teachers was either mathematics or a science teacher and the other was an English or history teacher. The data from the teacher questionnaires are also linked to the related student. Students selected for this sample were those for whom the data from their mathematics teacher questionnaire is available.

Data from the three questionnaires form the basis for the data that provides the independent variables used in this study. Students chosen for this research were those students for whom administrator questionnaire data were available. Students chosen for this research also were those for whom data from their mathematics teacher questionnaire were available. The data from the three questionnaires are integrated so that each individual student's data are linked to that of the student's school administrator's questionnaire and the student's teacher questionnaire.

Variables

The Dependent Variable: Mathematics Achievement of Black, Hispanic and White Students

Each student in the NELS:88 sample took the mathematics cognitive test which included 40 items and lasted 30 minutes. The mathematics cognitive test assessed simple mathematics application skills and included word problems, graphs, quantitative comparisons and geometric figures. Three versions of the mathematics cognitive test were developed at varying levels of difficulty. The particular mathematics test that was given to each student was based on their 1988 mathematics achievement score. The mathematics tests were administered in the spring of 1990, when the sample students were in their sophomore year in high school. Item Response Theory (IRT) was employed to calculate scores that could be compared regardless of which test form a student took. Scores were rescaled to a mean of 50 with a standard deviation of 10. The standardized mathematics test score serves as the dependent variable for this study.

Independent Variables

A standard multiple regression analysis is used to examine the potential effects of the independent variables identified in the literature review on mathematics achievement. The independent variables of primary interest are the three variables that reflect the level of Culturally Relevant Pedagogy of each student's mathematics teacher. In line with Ladson-Billings' (1994) theory, these are Conceptions of Self and Others, Social Relations, and Conceptions of Knowledge (Ladson-Billings, 1994). These three will be reviewed at some length at the conclusion of this section. The other independent variables include:

Gender: A dummy variable will be used for the gender independent variable with male as the reference category coded as zero and females coded as one.

Race/Ethnicity: Two dummy variables were created – one for blacks and one for Hispanics. For each dummy variable, white is the reference category and is coded as zero with black and Hispanic each coded as one.

Family Income: Based on the research of Spade, Columba & Vanfossen (1997) and Lee, Croninger & Smith (1997) family income is included as an independent variable. Earlier studies indicate a positive relationship between family income and the availability of advanced mathematics courses which provide an increased opportunity to learn for enrolled students. In the original survey, parents were asked to check a range of income category from fifteen options that best described their income. Rather than use the 1 – 15 coding for this variable which would lose information about the actual magnitude of income differentials among parents, the data were recoded to the midpoint of each income range category. For example, category 3 of \$1000 to \$2999 is now

represented by \$2000 and category 14 of \$100,000 to \$200,000 is now represented by \$150,000. With this recoding, the actual dollar difference among parents is more accurately represented.

Parent Education: Parent education is included in this multiple regression analysis for two reasons. The level of parent education is cited in both TIMSS 2003 and NAEP 2005 as having a positive relationship with their student's mathematics achievement. In addition, research by Choy, Horn, Nuñez, & Chen (2000), among others, indicates a positive relationship between the level of parent education and whether or not their student's schools offer algebra, the first level of the mathematics trajectory. The Parent Education variable is represented by three dummy variables: Parent Completed High School, Parent Completed Some College and Parent Completed College. For each dummy variable, the reference category Did Not Complete High School is coded as zero and the research variable is coded as one.

Percent of Students in School Qualifying for Free or Reduced-Price School Lunch: The variable reflecting the number of students who qualify for free or reduced-price school lunch serves as an indicator of the socioeconomic environment of the school. This variable is represented by two dummy variables: 11 percent to 50 percent in School Qualify for Free or Reduced-Price School Lunch and 51 percent to 100 percent in School Qualify for Free or Reduced-Price School Lunch. For each dummy variable, 0 percent to 10 percent Qualify for Free or Reduced-Price School Lunch is the reference category and is coded as zero with the research variable coded as one.

Tracking: According to research by Oakes (1985, 1990) and Useem (1992), tracking in the schools they researched suggested that students were assigned to

mathematics tracks along racial lines. This variable is a dummy variable with Tracking Not Practiced as the reference category and coded as zero and Tracking is Practiced coded as one.

Teacher Community: Research by Gutiérrez (1996, 1999, 2000) and Lee & Smith (1996) indicate that when students attend schools in which mathematics teachers collaborate in a professional community the students achieve more in mathematics. Teacher community is defined as an academic environment in which teachers share information about students and coordinate curricula. The question used in this study to measure teacher community is: I make a concerted effort to coordinate the content of my courses with teachers in my department/curricular area. This variable is coded to indicate the level of teacher agreement with this statement ranging from Strongly Disagree to Strongly Agree.

Measures of Culturally Relevant Pedagogy

The next explanatory variables measure the alignment of each mathematics teacher's beliefs and practices with the three components of Culturally Relevant Pedagogy. These three variables were constructed using questions and data from the NELS:88 First Follow Up Teacher Questionnaire. Questions from the Teacher Questionnaire were selected that were characterized by conceptual similarity to the description of Culturally Relevant Pedagogy provided by Ladson-Billings (1994). A factor analysis⁹ was conducted to determine if the 42 questions identified grouped together statistically to verify that they measured similar underlying concepts. Through this process, 27 questions were identified as grouping together to measure similar

⁹ "Factor analysis can also be used to reduce a large number of related variables to a more manageable number, prior to using them in other analysis such as multiple regression or multivariate regression analysis of variance." Pallant, J., 2005.

concepts. A reliability test, using Cronbach's Alpha as a standard of measure, was conducted to determine the strength of the correlation of the subgroups of questions relating to each of the three Culturally Relevant Pedagogy components. A Cronbach's Alpha¹⁰ of at least .7 was necessary to use the grouping of questions to measure one of the three Culturally Relevant Pedagogy components. For each of the three Culturally Relevant Pedagogy variables a set of questions, that reliability tests indicated measured the same concept, were grouped together. Within each set of questions, the Likert scale was identical.

Likert scale summated indices of those variables that the factor analysis and Cronbach's Alpha statistics indicated measured a similar concept were created. The variables in each of the respective summated indices were all scaled in the same manner for any given index. The summated index was divided by the number of items in the index in order to maintain the scale of the item that comprised the index.

Finally, five raters (current or former K-12 teachers) reviewed the correlated groups of NELS:88 Teacher Questionnaire questions and determined to which, if any, of the three Culturally Relevant Pedagogy Components (Conceptions of Self and Others, Social Relations or Conceptions of Knowledge) each group of questions conceptually related. From this, one group of NELS:88 Teacher Questionnaire questions was identified to measure each teacher's beliefs and practices relative to each of the three components of Culturally Relevant Pedagogy.

Conceptions of Self and Others: Conceptions of Self and Others refers to the student's relationship with mathematics, facilitated by their teacher. This teaching

¹⁰ "One of the most commonly used indicators of internal consistency is Cronbach's alpha coefficient. Ideally, the Cronbach's alpha coefficient of scale should be above .7." Pallant, J., 2005.

pedagogy stems from a belief that mathematics is part of everyday life and that all students can succeed in mathematics. Conceptions of Self and Others, was constructed using four questions from the NELS:88 Teacher Questionnaire. The four questions used for this variable were the following: 1) How much emphasis do you place on the importance of mathematics in everyday life?, 2) How much emphasis do you place on becoming interested in mathematics, 3) How much emphasis do you place on learning about applications of mathematics in business and industry?, 4) How much emphasis do you place on the important of mathematics in the applied sciences? Teachers responded to each question by indicating one of the four following options: 1) None, 2) A little, 3) Moderate, 4) Heavy. Based on a Cronbach's Alpha of .777, the responses to these four questions were strongly correlated. The responses from these four questions were added and then divided by four to create the continuous Likert scale index to measure Conceptions of Self and Others. The data from this variable create a score for each teacher for this variable. This score is then linked with the data, including the mathematics achievement score, of the particular students taught by each teacher. This variable, with a continuous scale, is used in the standard multiple regression.

Social Relations: Social Relations refers to the teacher's relationship with the student in the educational process. When a teacher's pedagogy is in line with Culturally Relevant Pedagogy the teacher is more likely to spend time with the student outside of the formal teacher/student relationship and is also more likely to communicate with the student's parent(s). Social Relations was constructed from four questions from the NELS:88 Teacher Questionnaire. These questions were as follows: 1) How many minutes did you spend communicating with parents in the last week?, 2) How many

minutes did you spend in academic counseling with students in the past week?, 3) How many minutes did you spend in personal counseling with students in the past week? 4) How many minutes did you spend tutoring students in the past week? Teachers responded to each of these four questions using the same scale: 1) None, 2) Less than 30 minutes, 3) 30 Minutes or more. Based on a Cronbach's Alpha of .712, the responses to these four questions were strongly correlated. The responses from these four questions were added and then divided by four to create a Likert scale index representing each teacher's score on the Social Relations component of Culturally Relevant Pedagogy. This score is then linked with the data, including the Mathematics Achievement score, of the particular students taught by each teacher. This variable, with a continuous scale, is used in the standard multiple regression.

Conceptions of Knowledge: Conceptions of Knowledge reflects how the teacher measures student progress in mathematics. Knowledge in mathematics is considered a complex standard with a variety of measures. Conceptions of Knowledge was constructed from three questions from the NELS:88 Teacher Questionnaire. These questions were as follows: 1) Indicate the importance of individual improvement in assigning grades, 2) Indicate the importance of effort in assigning grades, 3) Indicate the importance of class participation in assigning grades. Teachers responded to these three questions using the same scale: 1) Not important, 2) Somewhat important, 3) Very important, 4) Extremely important. With a Cronbach's Alpha of .783, the responses to these three questions were strongly correlated. The data from these three questions were added and then divided by three to create a Likert scale index representing each teacher's

score on the Conceptions of Knowledge component of Culturally Relevant Pedagogy.

This score is then linked with the data, including the mathematics achievement score, of the particular students taught by each teacher. This variable, with a continuous scale, is used in the standard multiple regression.

Interaction Variables

In order to more adequately explain the effects of each variable representing Culturally Relevant Pedagogy on the mathematics achievement of black and Hispanic students, six interaction variables were constructed which assess the multiplicative effect of race/ethnicity with each of the three variables representing Culturally Relevant Pedagogy, Conceptions of Self and Others, Social Relations and Conceptions of Knowledge. The interaction variables are: Conceptions of Self and Others * Black, Social Relations * Black, Conceptions of Knowledge * Black, Conceptions of Self and Others * Hispanic, Social Relations * Hispanic and Conceptions of Knowledge * Hispanic.

Table 1 provides a summary list of the dependent variable, mathematics achievement, and the independent variables included in this model.

Table 1 Summary list of the Dependent and Independent Variables

Variable Code	Variable Name	Variable Definitions
MA	Mathematics Achievement	Mathematics achievement
G	Gender (Male/Female)	Variable for gender of student with male as reference, Female = 1
D _B	Race – Black	Variable for black, with white as reference, Black = 1
D _H	Race – Hispanic	Variable for Hispanic, with white as reference, Hispanic = 1
FI	Family Income	Family income midpoint
PE _{HS}	Education – HS	Parent completed high school, did not complete high school as reference, Completed high school = 1
PE _{SC}	Education – SC	Parent completed some college, did not complete high school as reference, Completed some college = 1
PE _C	Parent Education – C	Parent completed college, did not complete high school as reference, Completed college = 1
SL ₁	Reduced Price School Lunch – 1	Entire School Percent Qualifying for School Lunch Between 11% and 50%, Qualifying between 11% and 50% = 1
SL ₂	Reduced Price School Lunch – 2	Entire School Percent Qualifying for School Lunch Between 51% and 100%, Qualifying between 51% and 100% = 1
T	Tracking	Group by Ability in Mathematics Courses Offered in Tenth Grade, with No Grouping as reference, Ability Grouping = 1
TC	Teacher Community	Practice of Teacher Coordination of Curricula, coded 1 to 6 (1 = strongly disagree, 2 = disagree, 3 = disagree somewhat, 4 = agree somewhat, 5 = agree, 6 = strongly agree)
CSO	Conceptions of Self & Others	Conceptions of Self and Others coded 1 to 4 (1 = no emphasis, 2 = little emphasis, 3 = moderate emphasis, 4 = heavy emphasis)
SR	Social Relations	Social Relations, coded 1 to 3 (1 = no time spent last week, 2 = .01 to .50 hours spent last week, 3 = .51 or more hours spent last week)
CK	Conceptions of Knowledge	Conceptions of Knowledge, coded 1 to 4 (1 = not important, 2 = somewhat important, 3 = very important, 4 = extremely important)
CSO*D _B	Conceptions of Self & Others * Black (Interaction Variable)	Conceptions of Self and Others * Black
SR*D _B	Social Relations * Black (Interaction Variable)	Social Relations * Black
CK*D _B	Conceptions of Knowledge * Black (Interaction Variable)	Conceptions of Knowledge * Black
CSO * D _H	Conceptions of Self * Others * Hispanic (Interaction Variable)	Conceptions of Self and Others * Hispanic
SR * D _H	Social Relations * Hispanic (Interaction Variable)	Social Relations * Hispanic
CK * D _H	Conceptions of Knowledge * Hispanic (Interaction Variable)	Conceptions of Knowledge * Hispanic

Mathematics Achievement: Standardized mathematics achievement test score (low of 31.45, high of 71.93)

Gender: Dummy variable, reference category is male

Race: Race_black – black, Race_Hispanic – Hispanic (Dummy variables, white as reference)

Family Income: Categories: \$0, \$500, \$2,000, \$4,000, \$6,250, \$8,750, \$12,250, \$17,500, \$22,500, \$30,000, \$42,500, \$62,500, \$87,500, \$150,000, \$250,000.

Parent Education: 1) Parent Education – parent completed high school, 2) Parent Education - parent completed some college, 3) Parent Education – parent completed college. (Dummy variables, Parent Education – parent did not complete high school as reference)

Percent Students Receiving Free or Reduced-price School Lunch: 1) School Lunch Percentage – 11% to 50% of students attending school qualify for free or reduced-price school lunch, 2) School Lunch Percentage – 51% to 100% of students attending school qualify for free or reduced price school lunch. (Dummy variables, 3) School Lunch – 0 – 10% of students attending school qualify for free or reduced-price school lunch as reference)

Tracking: Grouping by Ability for 10th Grade Math: Dummy variable with No Tracking as reference

Teacher Community: Category 1 = Strongly Disagree, 2 = Disagree, 3 = Disagree Somewhat, 4 = Agree Somewhat, 5 = Agree, 6 = Strongly Agree

Conceptions of Self & Others: Category 1 = No emphasis, 2 = A little emphasis, 3 = Moderate emphasis, 4 = Heavy emphasis

Social Relations: Category 1 = No time spent in last week, 2 = .01 to .50 hours in last week, 3 = .51 or more hours in last week

Conceptions of Knowledge: Category 1 = Not important, 2 = Somewhat important, 3 = Very important, 4 = Extremely important

Statistical Analysis to be Conducted

The analysis will be composed of four parts. In the first part, the mean mathematics achievement scores for selected variables at each point of measurement will be reviewed. In the second part the means and the standard deviations of the dependent variables and the independent variables will be presented.

The third part of the analysis will consist of a review of the mean scores for each of the variables within the model by race/ethnicity of study participants. An important component of this study is the differentiation of mathematics achievement along racial and ethnic lines and a number of the variables included in this model control for variables that previous research has identified as contributing to differences in mathematics achievement.

The fourth part of the analysis will be a review of the standard multiple regression results which are the center of this research. The standard multiple regression analysis will indicate the strength of the relationship between the variables in this model and the dependent variable of mathematics achievement.

Chapter Five: Results

Descriptive Statistics

Table 2 provides mathematics means scores for selected independent variables in this study. The data on Table 2 illustrates the positive and negative relationship between mathematics achievement and the independent variables listed.

Table 2
Mean Mathematic Achievement Scores for Selected Independent Variables
 Lowest mathematics score = 31.45; Highest mathematics score = 71.93;
 Overall mean mathematics score = 51.60

Gender	
Female	51.43
Male	51.76
Race	
Black	44.64
Hispanic	46.85
White	53.05
Family Income (by category midpoint)	
\$500	42.78
\$2,000	43.87
\$4,000	44.18
\$6,250	45.40
\$8,750	46.00
\$12,250	48.19
\$17,500	49.77
\$22,500	50.03
\$30,000	51.49
\$42,500	53.44
\$62,500	55.66
\$87,500	59.99
\$150,000	59.65
\$250,000	59.22
Parent Education	
Did not complete high school	44.52
Graduated from high school	48.45
Completed some college	50.70
Graduate from college	57.30
Percent of Students with Free or Reduced Lunch	
51-100%	46.67
11-50%	49.98
1-10%	54.00
Tracking	
School does not track	50.12
School tracks	52.11
There is a strong teacher community	
Strongly disagree	46.18
Disagree	49.71
Disagree somewhat	51.13
Agree somewhat	50.09
Agree	51.19
Strongly agree	53.03

The mathematics achievement data within this sample parallel that of the data cited previously (TIMSS 2003, NAEP 2005). Looking at means calculated from this data set, NELS:88 mathematics achievement scores range from a minimum of 31.45 to a maximum of 71.93 with a sample mean mathematics achievement score of 51.60. The mean score for white students is 53.05, followed by a mean score of 46.85 for Hispanics and 44.64 for blacks. The mathematics achievement scores of blacks are below those of Hispanics and whites at a statistically significant level. The mathematics scores of Hispanics are below those of whites at a statistically significant level. The mean scores for students whose parents' income midpoint is \$12,250 is 48.19, compared with the mean scores for students whose parents' income midpoint is \$62,500 at 55.66. The differences in mean scores are statistically significant. The mean mathematics achievement score for students whose parents are college graduates is 57.30 while the mean mathematics achievement score for students whose parents did not finish high school is 44.52. The difference between these mean scores is statistically significant. The mean mathematics achievement score for students attending schools with 1 – 10 percent of students qualifying for free or reduced-price school lunch is 54.00 while the mean mathematics achievement score for students attending schools in which 51 – 100 percent of students qualify for free or reduced-price school lunches is 46.67, a statistically significant difference. The mean mathematics scores for students whose schools practice tracking, or grouping by ability, do not differ greatly along the lines of this practice. The mean mathematics scores for students whose schools do track tenth graders is 52.11 compared with the mean mathematics score of 50.12 for students whose schools do not group tenth grade mathematics students by ability. The difference

between mathematics achievement scores for students whose teachers do and do not coordinate mathematics curriculum is statistically significant. The mean math score for students whose teacher strongly disagree with the practice of coordinating curricula is 46.18 compared with the mean score of 53.03 for students whose teachers strongly agree with the practice of coordinating curricula.

The means and standard deviations of the variables used in this study are presented in Table 3. They provide a general review of the population in this study. As noted earlier, the mathematics achievement reflected in this data set is in line with national and international mathematics achievement test results.

Table 3
Research Variables with Means and Standard Deviations
White N = 5247, Black N = 702, Hispanic N = 789

Variable	Mean	Standard Deviation
Mathematics Achievement (31.45 to 71.93)	51.60	9.9726
Gender (male, female) (female = 1)	49.62%	.5000
Family Income	\$43,259	40,931
Parent Education – Completed High School (completed high school = 1)	19.15%	.3935
Parent Education – Some College (Some college = 1)	38.59%	.4868
Parent Education – Completed College and More (College and more = 1)	30.69%	.4612
Percent Students in School Receiving Free or Reduced-Price School Lunch – 11% to 50% (11% to 50% qualify = 1)	40.51%	.4909
Percent Students in School Receiving Free or Reduced-Price School Lunch – 51% - 100% (51% to 100% qualify = 1)	8.30%	.2759
Tracking: Grouping on Ability for Math 10 th Grade (Practiced in Tenth Grade) (Tracking practiced = 1)	74.12%	.4380
Teacher Community	5.1064	.9347
Conceptions of Self & Others	2.9889	.5884
Social Relations	1.9175	.7904
Conceptions of Knowledge	2.6868	.6639

The population is fairly evenly divided by gender. For family income, with a range of \$0 to over \$250,000, the mean family income is \$43,259. In previous research, family income has been associated with stronger academic opportunities in the form of more rigorous mathematics curricula.

Reviewing the mean scores for parent education, 19 percent of parents of students in the study had only completed a high school education, whereas about 39 percent of parents had completed some college and about 31 percent had completed college. The remaining 11 percent of parents had not completed high school.

An indicator of the socio-economic circumstances of the school that students attend is the percentage of students attending that school who qualify for free or reduced-price school lunches. Within this study, 8 percent of students attended schools in which more than 50 percent of the students qualified for free or reduced-price school lunches. This is followed by about 41 percent of students attending schools where 11 to 50 percent qualify and then 51 percent attending schools where less than 10 percent of the students qualify for free or reduced-price school lunches.

In the measure of tracking, or grouping tenth grade students by their mathematics ability, about 74 percent of the students in this study attend a high school where tenth grade students are grouped by mathematics ability.

Teacher Community refers to the practice of teachers of coordinating their curricula so that mathematics courses interface with each other smoothly. For the population in this survey, in a range from 1 indicating a low incidence of this practice to 6 indicating a high incidence of this practice, the mean score is about 5. This indicates that most students attend a high school where their mathematics teachers coordinate their curricula.

Conceptions of Self and Others refers to the practice of mathematics teachers emphasizing an awareness of mathematics in everyday life, emphasizing an interest in mathematics, emphasizing the application of mathematics in business and industry and

emphasizing an awareness of the importance of mathematics in basic and applied sciences. The range for this variable is 1 to 4, with 1 indicating a low incidence of this practice and 4 indicating a high incidence of this practice. The mathematics teachers of the students in this study have a mean score of almost 3, suggesting that the incidence of this practice emphasizing the use of mathematics in everyday life and its applications in a variety of fields is fairly high.

The Social Relations variable measures the practice of the mathematics teacher of spending time with his or her students outside of the formal classroom setting and teaching relationship. The range of this variable is 1 to 3, with 1 indicating a low incidence of this practice and 3 indicating a high incidence. The teachers in this study have a mean score of almost 2 indicating that some teachers follow this practice.

The Conceptions of Knowledge variable measures the practice of the mathematics teacher of grading in mathematics based on a student's improvement over past performance, a student's effort in class and a student's class participation. The range for this variable is 1 to 4, with 4 indicating a higher incidence of this practice. The mean score for this variable is about 2.7, indicating a somewhat common incidence of this practice

Mean Scores by Race and Ethnicity

A review of the means of the variables as they differ by race and ethnicity, white, black and Hispanic, shown in Table 4, further highlights some of the variation in each variable. As cited earlier in this chapter, the mean mathematics achievement score is highest for whites, followed by Hispanics with blacks scoring the lowest. The regression

analysis that follows seeks to identify sources of the variation in mathematics achievement score by race and ethnicity.

Table 4
Means by Race and Ethnicity

Variable	White	Black	Hispanic	Races Combined
Mathematics Achievement Average	53.05	44.64	46.85	51.45
Gender				
Male (N)	2620	358	409	3387
Female (N)	2627	344	380	3351
Race (N)	5247	702	789	6738
Family Income	\$47,170	\$25,375	\$29,339	43,085
Parent Education				
High school	.2009	.1952	.1762	.1974
Some college	.3936	.4330	.3511	.3927
College plus	.3415	.1752	.1470	.3014
Percent in School Qualify for Free or Reduced Price School Lunch				
11% - 50%	.3871	.5128	.4398	.4064
51% - 100%	.0446	.2051	.2155	.0813
Teacher Community				
1 (Strongly disagree) to 6 (strongly agree)	5.1361	4.9343	5.0171	5.1016
Tracking				
Tracking practiced = 1	.7383	.7479	.7186	.7370
Conceptions of Self & Others				
1 (no emphasis) to 4 (heavy emphasis)	2.9778	3.0686	3.0357	2.9937
Social Relations				
1 (Least amount of time) to 3 (Most amount of time)	1.8944	2.0146	1.9449	1.9124
Conceptions of Knowledge				
1 (no importance) to 4 (extremely important)	2.6512	2.8956	2.7735	2.6905

The mean score for family income is \$47,140 for parents of white students, almost double that of parents of black students and somewhat less than double that of parents of Hispanic students.

In this study, the percent of parents who have only completed high school differs little by race and ethnicity, with 20 percent of white and black parents followed by 18 percent of Hispanic parents in this category. There is a little more variation by race and ethnicity of parents who have completed some college, with 43 percent of black parents, 39 percent of white parents and 35 percent of Hispanic parents falling into this group. The variation grows for parents who have completed college with 34 percent of white parents, 18 percent of black parents and 15 percent of Hispanic parents in this category. The remaining parents who did not complete high school are 32 percent Hispanic, 19 percent black and 7 percent white.

Researchers often use the number of students attending a school who qualify for free or reduced-price school lunch as an indicator of the socioeconomics of the school environment. There is variation along racial and ethnic lines for this variable. Of those students who attend schools where less than 10 percent of the students qualify for free or reduced-price lunches, 57 percent are white, 34 percent are Hispanic and 28 percent are black. In schools where 11 to 50 percent qualify, 51 percent are black, 44 percent are Hispanic and 39 percent are white. Finally, in schools where over 51 percent of the students qualify, 22 percent are Hispanic, 21 percent are black and 4 percent are white.

The measure of frequency with which mathematics teachers in each student's school coordinate their mathematics curricula to ensure a smooth transition into each mathematics class also indicates little variation by race or ethnicity of the student. The data indicates that coordination of curricula (Teacher Community) is fairly common practice. Similarly, data indicates that the practice of tracking, or grouping tenth graders by their mathematics ability, is fairly common and does not differ greatly by the race or

ethnicity of the student. There was also little variation along racial or ethnic lines for the three variables measuring Culturally Relevant Pedagogy: Social Relations, Conceptions of Self & Others and Conceptions of Knowledge.

Model Results

Regression Model

$$\begin{aligned} MA = & a + b_1G + b_2D_B + b_3D_H + b_4FI + b_5PE_{HS} + b_6PE_{sc} + b_7PE_c + b_8SL_1 + b_9SL_2 + b_{10}T \\ & + b_{11}TC + b_{12}CSO + b_{13}SR + b_{14}CK + b_{15}CSO*D_B + b_{16}SR*D_B + b_{17}CK*D_B + \\ & b_{18}CSO*D_H + b_{19}SR*D_H + b_{20}CK*D_H \end{aligned}$$

Where:

G = gender (F = 1)

D_B = race (black = 1)

D_H = race (Hispanic = 1)

FI = family income

PE_{HS} = parental education (parent completed high school = 1)

PE_{SC} = parental education (parent completed some college = 1)

PE_C = parental education (parent completed college = 1)

SL₁ = reduced school lunch (between 11% and 50% = 1)

SL₂ = reduced school lunch (between 51% and 100% = 1)

T = tracking (high school offers math tracks by ability = 1)

TC = teacher community (1 to 6 where 1 = is strongly disagree and 6 is strongly agree)

CSO = conceptions of self and others (1 to 4 where 1 = no emphasis and 4 = heavy emphasis)

SR = social relations (1 to 3 where 1 = no time spent and 3 = .51 or more hours spent)

CK = conceptions of knowledge (1 to 4 where 1 = not important and 4 = extremely important)

CSO*D_B = conceptions of self and others * black

SR*D_B = social relations * black

CK*D_B = conceptions of knowledge*black

CSO*D_H = conceptions of self and others * black

SR*D_H = social relations * black

CK*D_H = conceptions of knowledge*black

The multiple regression results are shown in Table 5. Dependent and independent variables are described in the previous section. The R Square for this model is .252, indicating that this model explains 25.2% of the variation in the dependent variable, mathematics achievement.

Table 5**Standard Multiple Regression Results**

Independent Variables	B Coefficient	Std. Error	Sig.
Constant	48.659	1.075	.000
Gender (Female = 1)	-.288	.234	.218
Race_black (Black = 1)	-12.492	2.564	.000
Race_Hispanic (Hispanic = 1)	-11.693	2.397	.000
Family Income	.0000262	.000	.000
Parent Education, High school (High school = 1)	2.731	.671	.000
Parent Education, Some college (Some college = 1)	4.748	.642	.000
Parent Education, College plus (College plus = 1)	9.510	.658	.000
School lunch, 11% - 50% In school qualify (11% to 50% qualify = 1)	-.830	.260	.001
School lunch, 51% - 100% In school qualify (51% to 100% qualify = 1)	-1.353	.471	.004
Tracking/10 th Grade Grouping by Math Ability (Tracking practiced = 1)	.789	.273	.004
Teacher Community (1=Strongly disagree to 6 = Strongly agree)	.630	.129	.000
Conceptions of Self & Others (1= No emphasis to 4 = Heavy emphasis)	-.097	.240	.683
Social Relations (1= No time spent in week to 3 = .51 or more hours spent in week)	.499	.171	.004
Conceptions of Knowledge (1=Not important to 4 = Extremely important)	-1.178	.212	.000
Conceptions of Self & Others and Black	1.765	.758	.020
Social Relations and Black	.133	.538	.804
Conceptions of Knowledge and Black	.325	.650	.617
Conceptions of Self & Others and Hispanic	1.920	.686	.005
Social Relations and Hispanic	.645	.497	.194
Conceptions of Knowledge and Hispanic	.520	.612	.396
R-Square = .252			

Examining the variables that prior research suggest as important in explaining mathematics achievement, both race variables are negatively related to mathematics achievement and are statistically significant. This supports earlier research findings that black and Hispanic students score lower on mathematics achievement tests.

Family Income is positive in its relationship to mathematics achievement and is statistically significant. The relationship between the Parent Education variables and mathematics achievement is also positive and becomes a stronger positive with higher levels of Parent Education. Another socioeconomic variable in this model is that representing the percentage of students in each student's high school who qualify for free or reduced-price school lunches are negative and significant. The size of the negative coefficient rises in absolute terms with the larger percentage of students receiving free or reduced-price school lunch. The positive relationship between Family Income and Parent Education and mathematics achievement and the negative relationship between the percentage of students qualifying for free and reduced-price school lunches and mathematics achievement are consistent with previous research and suggests that socioeconomic circumstances are important predictors of mathematics achievement.

The relationship between mathematics achievement and the practice of tracking, or grouping tenth grade students by their mathematics ability, is positive and statistically significant. Thus, tracking improves mathematics test results. Teacher Community measures the strength of the practice of mathematics teachers coordinating curricula. The variable measuring the relationship between teacher community and mathematics achievement is positive and statistically significant. Previous research cites similar results.

There are three variables that represent Culturally Relevant Pedagogy. Of these three, the coefficients of two are statistically significant. The Social Relations variable, which measures the amount of time the teacher spends with the students outside of the formal teaching relationship, is positive and statistically significant. The Conceptions of

Knowledge variable, which measures the grading practice of the teacher as based on student improvement, effort and class participation, produced a statistically significant negative coefficient. Although Ladson-Billings (1994, 1995a, 1995b) theory would expect a positive result for this variable, the results are not surprising when one considers the model for grading achievement as reflected by the mathematics achievement test and the very different model for grading achievement that is represented by the Conceptions of Knowledge variable. This will be discussed in more detail later. The Conceptions of Self & Others variable is insignificant.

The interaction terms are used to examine whether the Culturally Relevant Pedagogy variables have different impacts on mathematics achievement based on race or ethnicity. Among the interaction terms, only the interaction between Conceptions of Self and Others * blacks and Conceptions of Self and Others * Hispanics are significant. The positive sign on both coefficients suggests that teachers who help students to see mathematics in everyday life and to see the various applications of mathematics in business and in the sciences will have a positive impact on the mathematics achievement scores of black and Hispanic students.

Chapter Six: Discussion and Interpretation

The results of this study support those of prior researchers and highlight the importance of gaining a better understanding of what causes differences in mathematics achievement and what can be done to increase the mathematics achievement of black and Hispanic students.

Socioeconomic conditions clearly have a strong impact on mathematics achievement. Family Income and Parent's Highest Education Level with completed college and beyond have a strong and positive impact on mathematics achievement. These two variables, Family Income and Parent's Highest Education, also follow the pattern of mathematics achievement means by race and ethnicity, with Family Income and Parent's Highest Education each having the highest mean for whites, followed by Hispanics and then followed by blacks. This is consistent with previous research which suggests a relationship between family income and parent education and the mathematics achievement of their student. The negative relationship between the percentage of students attending the school who qualify for free or reduced-price school lunches and mathematics achievement is also consistent with previous research. For the school lunch variable, a higher percentage of black and Hispanic students attend schools with more students qualifying for free or reduced-price school lunches. These three socioeconomic variables each have a statistically significant relationship with mathematics achievement, suggesting that higher socioeconomic status is associated with stronger mathematics achievement. Further, the mean scores for black and Hispanics students suggest that

these students are more likely to be in lower socioeconomic circumstances than are white students..

While tracking, or grouping by mathematics ability in mathematics is positively related to achievement, attending schools where tracking is practiced is no more common for black and Hispanic than for white students. The variable for Teacher Community, or the practice of coordinating mathematics curricula, is also positive. Mean scores indicate that this practice does not fall along racial or ethnic lines, but that it is fairly common in all of the schools in the study. As with Tracking, Teacher Community does not account for variation of mathematics achievement along racial/ethnic lines based on means. However, the positive relationship between teacher community and mathematics achievement is consistent with previous research.

The Social Relations coefficient indicates a positive relationship with mathematics achievement. This would suggest that when teachers spend more time with their students outside of the formal teaching relationship in the classroom, their students will achieve more in mathematics. Ladson-Billings (1994, 1995a, 1995b) asserts that in most classrooms, the teacher and student relationship is fixed and hierarchical and that teachers develop an environment in which students learn mathematics in isolation. She argues that a different approach of the teacher establishing a more fluid and less hierarchical relationship with the student will improve mathematics achievement. These results suggest that this is the case.

The Conceptions of Knowledge coefficient indicates a negative relationship with mathematics achievement. These criteria for setting grades (improvement, effort and class participation) are presented as more complex and varied than the fairly specific

standards which are used to score the study participants' performance on the mathematics achievement test that was part of this study. The measure of mathematics achievement in this study is a different measure of mathematics achievement than that represented by the theory of Culturally Relevant Pedagogy as embodied by Conceptions of Knowledge. Ladson-Billings' (1994, 1995a, 1995b) understanding of this pedagogy is to meet a student where he or she is, build their confidence in their mathematics ability and improve their mathematics achievement through this teaching practice. Within the confines of this study, the practice of grading by these guidelines has a negative effect on mathematics scores; however, as discussed in the next section, this research represented a cross section of data, the effect of one year of this teaching pedagogy on mathematics achievement. Future studies may explore the longitudinal effect of this pedagogy on a student's ability to perform well on a standardized mathematics achievement test.

The Conceptions of Self and Others variable is insignificant related to mathematics achievement. When compared to the statistically significant relationship between the interaction variables of Conceptions of Self * Black and Conceptions of Self * Hispanic, these results suggest that this pedagogy does not impact the mathematics achievement of the large number of white students whose mathematics achievement is included in this result. However, the interaction variables of Conceptions of Self and Others * Black and Conceptions of Self and Others * Hispanic produced positive coefficients, suggesting that when teachers follow a teaching pedagogy represented by Conceptions of Self and Others, black and Hispanic students will have stronger mathematics achievement. There is a multiplicative interaction between these variables that explains more of the variation of mathematics achievement by race and ethnicity. To

review, Conceptions of Self and Others is the teaching pedagogy of developing an awareness of the importance of mathematics in everyday life, becoming interested in mathematics and learning about the application of mathematics in every day life and its application in business and the sciences. The mathematics programs described in Chapter Three “demystify” mathematics by reducing the emphasis on abstract terms and formulas and emphasizing real world applications, especially early in the curricula. Many mathematics teachers in these experimental programs, like those of Escalante and Moses, with the goal of increasing the mathematics achievement of low income, black and Hispanic students, teach mathematics through the use of manipulatives and other creative techniques that move away from the presentation of mathematics as an abstract curriculum. These educators are working with a different form of mathematics education that also makes mathematics more a part of the every day life of the students.

This model explained 25.2% of the variation in the dependent variable, mathematics achievement. Although this is not an unreasonably low R Squared, it does indicate that there is much about the variation in mathematics achievement especially along racial and ethnic lines that we do not yet understand. Given the significance of the racial dummy variables, it is clear that these variables serve as a proxy for other undiscovered factors that impact mathematics achievement.

Future Research

Ladson-Billings’ (1994, 1995a, 1995b) Culturally Relevant Pedagogy is worthy of more investigation among populations other than the grade school children she researched. My research examined the effect of Culturally Relevant Pedagogy on the

mathematics achievement of black and Hispanic tenth grade students. Future research on the effect of Culturally Relevant Pedagogy on the mathematics achievement of black and Hispanic high school students that is longitudinal in nature would provide valuable information on the long term or cumulative effects of Culturally Relevant Pedagogy. Even in a one year study, significant effects of Culturally Relevant Pedagogy on the mathematics achievement of black and Hispanic students was suggested. Further research to explore the interactive effect of race and the elements of Culturally Relevant Pedagogy may provide more depth of understanding and possibilities for improving the mathematics achievement of all students.

Many of the other variables in the multiple regression analysis that are known to influence mathematics achievement, such as family income and parent's highest education, may have been at work in each student's life for many years previous to the tenth grade year captured in this research. Research of the effects of Culturally Relevant Pedagogy over time may produce different results. Anecdotal efforts and other research suggest that there may be unrealized potential in further understanding and utilizing the impact of culturally sensitive teaching pedagogies when teaching black and Hispanic students.

In this research, the multiplicative effective of Conceptions of Self and Others * black and Conceptions of Self and Others * Hispanic produced positive and statistically significant results. These results bear more research to learn why these interactive terms have a positive effect on mathematics achievement for black and Hispanic students relative to white students.

As noted earlier in the research by Love and Kruger (2005), there may be value in exploring differences in mathematics achievement *within* each racial and ethnic group. Research to explore the effects of these independent variables on the differences in mathematics achievement within racial and ethnic groups may help to further understand the strong relationship between race and ethnicity and mathematics achievement.

Chapter Seven: Policy Review

The following serves as a summary of significant federal and state legislative and judicial activity toward the end of correcting inequities in public education often resulting from differences of the socioeconomic and racial differences in recipients of public education. This paper will conclude with a review of recent judicial and legislative activity in the Commonwealth of Massachusetts also toward the end of addressing inequities in public education.

Brown v. Board of Education (1954)

Brown v. Board of Education (1954) served as a turning point in the review of public education as it is provided to US citizens. Citing the Fourteenth Amendment, the court determined that “segregation, denies Negro children the equal protection of the laws guaranteed by the Fourteenth Amendment...” Brown v. Board of Education (1954). Chief Justice Warren decision for the Court included statements of value in line with the perpetuation of a democracy, including: “Today, education is perhaps the most important function of state and local governments....In these days, it is doubtful that any child may reasonably be expected to succeed in life if he is denied the opportunities of an education.”, Brown v. Board of Education (1954). Brown v. the Board of Education (1954) was a class action suite brought forward on behalf of plaintiffs in four states, Delaware, Kansas, South Carolina, Virginia and Washington D.C. In all cases, plaintiffs from each state had unsuccessfully filed cases in their jurisdictions seeking relief from their Negro children being required to attend schools that were segregated and significantly substandard in location, physical plant and quality of education to the education being provided to white students within the jurisdiction.

San Antonio School District v. Rodriguez (1973)

About twenty years later, the legal issue of the responsibility of the state and local government to provide equal education to all of its citizens was still being debated and decided. In the *San Antonio School District v. Rodriguez (1973)*, the Supreme Court heard an appeal of the decision by the District Court of Texas, *San Antonio Independent School District et al., v. Rodriguez et al.* The District Court found for the plaintiffs in a class action suit on behalf of families of children attending schools in the Edgewood Independent School District, serving primarily low-income Mexican-American students. The Texas District Court found “the Texas school finance system finance system unconstitutional under the Equal Protection Clause of the Fourteenth Amendment.”.

The Supreme Court’s decision in this case also served as a turning point in public education law and public education reform. The Supreme Court found for the State of Texas and overturned the District Court’s decision. Chief Justice Powell delivered the opinion of the Court. In his opinion, he stated “Though education is one of the most important services performed by the State, it is not within the limited category of rights recognized by this Court as guaranteed by the Constitution.”, *San Antonio School District v. Rodriguez (1973)*.

With this decision, education equity became a matter for the states to resolve, one at a time. According to the Access Quality Education: School Funding Litigation web site (<http://www.schoolfunding.info/litigation/litigation.php3>), lawsuits that challenge states in their funding of public schools have been brought forward in 45 of the 50 states. Of these, 26.5 are noted as having been decided for the plaintiff and 17.5 for the state, with one pending.

Serrano V. Priest (1971)

Following the Rodriguez decision, state lawsuits ensued. The first of these brought suit, before Rodriguez, based on violation of the state Equal Protection Clause. Noteworthy of these first suits is Serrano v. Priest (1971). This California suit was a class action suit to challenge the school funding schemes that divided services into those for the haves and those for the have-nots. The Court found for the plaintiffs in this case, finding that the system of funding public schools in California was in violation of the Fourteenth Amendment as school funding varied greatly depending on the property-tax base attached to each public school. The U.S. Supreme Court's decision in San Antonio School District v. Rodriguez in 1973, two years later, removed the basis of the Serrano v. Priest decision. The Serrano v. Priest decision was revisited [Serrano v. Priest (1976) and Serrano v. Priest (1977)] in the midst of tax reform efforts to address the inequity in funding for California public schools. Although the Serrano v. Priest cases drew attention to education inequity in California, the results did not provide other states with a hopeful model to follow.

Rose v. Council for Better Education (1989)

In a change in direction in state lawsuits to address education inequity, some plaintiffs began to pursue the issue of inequity in public education from equal protection to adequacy, as stated in the education clause of most state constitutions. This approach has produced more tangible results, as exemplified by the key case in this category of Rose v. Council for Better Education (1989). In another class action suit, "66 property-poor rural school districts" (Access Quality Education: Kentucky Litigation) in

Kentucky filed suit claiming that the state’s educational funding system was in violation of its constitution. The Court agreed and found for the plaintiffs. What is most helpful about the Court’s decision is that it spelled out researched standards by which to measure an adequate education. This language has been used by courts that have since found for plaintiffs that their state is in violation of the adequacy clause of its constitution. The language is so clear and helpful that it merits inclusion:

The seven learning goals, for “each and every child,” are

1. sufficient oral and written communication skills to enable students to function in a complex and rapidly changing civilization;
2. sufficient knowledge of economic, social, and political systems to enable the student to make informed choices;
3. sufficient understanding of governmental processes to enable the student to understand the issues that affect his or her community, state, and nation;
4. sufficient self-knowledge and knowledge of his or her mental and physical wellness
5. sufficient grounding in the arts to enable each student to appreciate his or her cultural and historical heritage;
6. sufficient training or preparation for advanced training in either academic or vocational fields so as to enable each child to choose and pursue life work intelligently; and
7. sufficient levels of academic or vocational skills to enable public school students to compete favorably with their counterparts in surrounding states, in academics or in the job market.

Rose v. Council for Better Education (1989)

Legislative and Judicial Efforts on Educational Equity in the Commonwealth of Massachusetts

Like many states, the Commonwealth of Massachusetts has been the site of judicial cases seeking relief from education inequity. In addition, the Commonwealth has worked to draft legislation to improve the quality of education delivered to all residents, those living in low income areas as well as all others.

McDuffy v. Secretary of the Executive Office of Education (1993)

A key court decision affecting education reform in the Commonwealth of Massachusetts was that of *McDuffy v. Secretary of the Executive Office of Education* 415 Mass. 545, 621 (1993). The plaintiffs in this case were sixteen students living in and attending schools in sixteen less affluent districts of Massachusetts. The plaintiffs claimed that the Commonwealth of Massachusetts was in violation of the Education Clause of its Constitution because it was not providing an adequate education to all of its citizens. The Court found for the plaintiffs. As part of its decision, the Court outlined the educational standards included in the *Rose v. Council for Better Education* (1989) decision in which the Kentucky Court also found for the plaintiffs and ordered compliance by the Commonwealth of Massachusetts with compliance with these standards.

Education Reform Act (ERA) of 1993

Three days after the *McDuffy* decision, the Commonwealth of Massachusetts passed the Education Reform Act of 1993. Many of the provisions of this legislation were in line with compliance with the *McDuffy* decision. The Education Reform Act of 1993 (ERA) outlined significant changes in public education in Massachusetts to be

enacted over a seven year period of time. The major provisions of the ERA outlined processes to ensure more equitable school funding, higher accountability for student learning and the implementation of statewide standards for students, educators, schools and districts.

A foundational budget was established to bring all schools to a foundational level of spending, regardless of the income level of the district. Differences in funding took into consideration the fiscal means of the various districts.

Another significant reform resulting from the ERA was the implementation of curriculum frameworks and learning standards for all students in the core academic subjects, resulting in the Common Core of Learning guidelines. Stemming from revisions in the academic curriculum for public school students was the implementation of a required statewide achievement test name the Massachusetts Comprehensive Assessment System (MCAS). MCAS is taken by all fourth-grade, eighth-grade and tenth-grade students. Students must pass the MCAS in order to receive a high school diploma. The results of the MCAS are to be used to identify students who need additional attention.

The ERA also made provisions for the establishment of charter schools sanctioned by the Board of Education and open to all students and meeting the same standards and testing requirements set by the Board of Education for public schools.

Additional provisions of the ERA included setting standards and learning, with at least 900 hours in the elementary schools and 990 hours in the secondary schools spent on core academic subject areas. Teacher testing for new teachers in knowledge of subject content and communication and literacy skills were implemented as well as subject

matter testing for returning teachers. (Secretary of Education's Progress Report, May 1997).

Hancock v. the Commissioner of Education (2005)

In 1999, plaintiffs from nineteen low-income school districts went to court claiming that the Commonwealth of Massachusetts had not complied with the McDuffy decision. The plaintiffs claimed that the Commonwealth of Massachusetts had neglected its constitutional responsibility to comply with the previous court order. In 2004, in the Trial Court, Judge Botsford investigated the claims of the plaintiffs and believed that they had merit. In 2005, however, Judge Marshall of the Supreme Judicial Court disagreed and found for the Commonwealth, *Hancock v. Commissioner of Education (2005)*. In her decision, Judge Marshall indicated that she found that the Commonwealth of Massachusetts had made significant strides in education reform since the 1993 McDuffy decision and the enactment of the Education Reform Act of 1993. Although Judge Marshall found for the Commonwealth, she also included language in her decision affirming that the Commonwealth was responsible to provide an adequate education for all public school children, regardless of the financial circumstances of their school district.

Summary

In *Brown v. the Board of Education (1954)* the Court held that education is a function of the government and that all children must have access to the opportunities embodied in education in order to succeed in life. In the *San Antonio School District v. Rodriguez (1973)*, the Supreme Court held that education is not a right guaranteed under

the Federal Constitution. Education became the responsibility of each state, as determined by each state's constitution.

In the state lawsuits claiming that public education was not being provided to all citizens, equity suits were the first suits. Of the noteworthy suits were the series of *Serrano v. Priest* (1971, 1976, 1977) suits in California which tackled education in equity from a primarily financial equity basis without good result. State education lawsuits later based their claims on “adequacy”, the standard set for education in many state constitutions. One of the most helpful court decisions in an adequacy case was in *Rose v. Council for Better Education* (1989) in which the Kentucky court found for the plaintiff. In its decision in the *Rose* case, the Kentucky court outline specific standards for a quality education that the State of Kentucky was directed to follow. Since this decision, many courts finding for the plaintiffs in education equity cases use the *Rose* decision language in their decisions.

Massachusetts is an example of one case using the language from *Rose v. Council for Better Education* (1989). In *McDuffy v. Secretary of the Executive Office of Education* (1993), plaintiffs from less affluent school districts in Massachusetts claimed that the Commonwealth was in violation of the education clause of its Constitution because it was not providing an adequate education to all of its citizens. The Court agreed and found for the plaintiffs, using language from the *Rose* decision in its mandate for compliance to the Commonwealth of Massachusetts.

At about the same time the *McDuffy* case was decided, the Massachusetts legislature passed the Education Reform Act (ERA) of 1993. The ERA sought to address many of the issues that underpinned the *McDuffy* case. Included in its structure was an

overall of educational funding to ensure a more equitable per student spending formula for all districts regardless of wealth. Also included was a mandate for curriculum reform, required student testing and teacher testing.

In 1999, plaintiffs from sixteen lower-income school districts in Massachusetts brought suit claiming that the Commonwealth had not complied with the directives resulting from *McDuffy v. Secretary of the Executive Office*. In 2005, in *Hancock v. the Commissioner of Education*, the Court found for the Commonwealth and indicated that the Commonwealth had made progress toward educational goals. The Court affirmed the responsibility of the Commonwealth to continue its progress in this area.

Serrano v. Priest (1971) tried to unsuccessfully address education inequity primarily through an adjustment of the tax system and related finances. This is not unlike the research reviewed in this paper in which researchers have not been able to sort through the relationship between financial resources and student achievement. We believe there is a relationship, but defining it in a way that leads to solutions as proven difficult.

The *Rose v. The Council for Better Education* (1989) decision, with its specific mandate for quality of education, parallels the Principles and Standards for School Mathematics (2000) set by the National Council of Teachers of Mathematics. The *McDuffy v. Secretary of the Executive Office of Education* (1993) affirmed the *Rose* decisions.

The Education Reform Act of the Commonwealth of Massachusetts combined many elements of this research. The ERA sought to correct funding per pupil so that the tax base was not the primary determiner of educational funding – along the lines of the

research seeking to determine the relationship between economics and quality education. The ERA also set a core curriculum, also in line with researchers whose findings suggest that regardless of their educational history, students who are enrolled in “important math” will progress and achieve. The ERA set up required achievement testing to determine outcomes and increase accountability. The ERA set teacher testing standards in acknowledgement of the impact of the teacher on student success. Although the court decided for the Commonwealth in *Hancock v. the Commissioner of Education* (2005), the Courts decision included the proviso that the Commonwealth has work left to do and it will be held accountable.

In many ways, the above-cited legislative and judicial activity parallels the activities of educators and researchers to address the problem of lower achievement by low income, often minority, students. Court cases and legislation at the federal level and in various states have addressed the twin issues of racial and financial inequality of education provided in public schools. While efforts to address education inequity from a purely financial perspective have met with limited success, later efforts to address education inequity from the perspective of teaching practices and educational outcomes have met with more success. As the research in Chapter Two suggests, providing an environment where all children can succeed in mathematics goes beyond the minimum of providing financial resources. In many ways, case law and legislative activity parallel the work of researchers and educators as they work to determine how best to ensure that all children, regardless of socioeconomic circumstances, receive a public school education that will prepare them to earn a living, attend college, and participate fully in society.

Chapter Eight: Summary

Mathematics can be considered a litmus test of the condition of public education. It is a critical curriculum that increases in importance as a body of knowledge necessary to progress academically and to, ultimately, be employable at a reasonable level in today's evolving global and technology-driven economy. The purpose of this research was to understand the impact of Culturally Relevant Pedagogy on the mathematics achievement of black and Hispanic high school students. Why is this topic worthy of investigation?

The Trends in International Mathematics and Science Study (TIMSS) 2003 is a test facilitated in over forty countries. The US performs below many countries, including those with whom we must compete economically. US students who are black and Hispanic have lower math scores than white students, at a statistically significant level. US students who qualify for free or reduced-price school lunch score below students who do not qualify for free or reduced-price school lunch, also at a statistically significant level. Results of the National Assessment of Educational Progress (NAEP) 2005 are similar. In addition, NAEP reveals a positive relationship between the level of parent education and mathematics achievement.

As noted in Chapter One, mathematics achievement for US students is more important now than it was forty years ago due to the globalization of the economy. Many of the jobs that do not require a college education or mathematics skills are no longer done in the US but in other countries where the labor costs are lower. Industry growth is significant in areas requiring technology and the associated mathematics skills. More and

more industries require mathematics skills and a college education. High school mathematics is a gateway curricula for college. Students who have not taken “important” mathematics courses in the mathematics trajectory from Algebra I to Calculus have more difficulty gaining admission to college than those who have enrolled in the mathematics trajectory. Students with poor mathematics preparation will have difficulty gaining access to the college that is more necessary for employment in today’s globalized and increasingly technology- and mathematics-drive economy.

A number of researchers have worked to understand the causes of the above-noted disparities in mathematics achievement along racial/ethnic and socioeconomic lines. Research in tracking pursues the hypothesis that because minority and low-income students are disproportionately placed in low level non-academic mathematics classes their mathematics achievement is lower. Research in curriculum investigates the belief that the level of mathematics in which a student is enrolled, regardless of academic history, will influence the student’s mathematics achievement. Much of what is written about mathematics curricula refers to the mathematics trajectory, which generally begins with Algebra I in junior high and ends with calculus in high school. Research on the effect of access to educational resources and mathematics achievement pursues the idea that when students are afforded greater access to resources, defined in a number of ways, they will achieve more in mathematics. The research in this area is inconclusive.

Research on teacher community pursues the thinking that teacher behaviors can influence student achievement. Many think of teachers as working in isolation and managing their own classroom. Teacher practices associated with stronger mathematics achievement included coordination of curriculum, sharing information about students,

using creative teaching pedagogies/techniques and being available for students outside of class time.

One can think of the factors of influence on a student's mathematics as falling on a point of a continuum with the teacher as the main factor on one end and the student as the main factor on the other end. Research on student effort explores the student end of the continuum, arguing that students do not achieve in mathematics because they do not expend effort, but the research did not support this. Rather, research suggested that black and Hispanics students invest as much effort in their education as white students, although white students seem to achieve more when investing the same amount of effort.

A number of researchers have worked to learn more about the relationship between pedagogy and mathematics achievement. The research reflected in this paper is based on Ladson-Billings' (1994, 1995a, 1995b) theory of Culturally Relevant Pedagogy. Ladson-Billings argues that students whose teachers use Culturally Relevant Pedagogy will achieve more academically, will demonstrate cultural competence and will understand and critique the existing social order.

The research in this dissertation is based on Ladson-Billing's first assertion – that students whose teachers use Culturally Relevant Pedagogy will achieve more. Culturally Relevant Pedagogy is divided into three categories. The first category is Conceptions of Self and Others which represents a teacher's belief that all students can succeed and that it is important for students to take an interest in mathematics and to learn that mathematics is found in their everyday life and in the various professional environments around them. The second category is Social Relations which represents the belief that student/teacher relationships are fluid and are not limited to the formal classroom setting.

The third category is Conceptions of Knowledge which represents the belief that grades should not be strictly based on an inflexible criteria, but on student effort, student improvement and student participation in class.

The data used for this research is from the First Follow Up Year of the National Educational Longitudinal Study of 1988 (NELS:88). NELS:88 is a longitudinal study of 24,599 eighth graders attending 1,052 schools in the US, ensuring that the sample was representative of US students at large. Students identified for this specific research were those who had a teacher and school administrator questionnaire and mathematics achievement test scores attached to their data and students who were white, black or Hispanic. This resulted in an sample of 6738 students: 5247 white, 702 black and 789 Hispanic.

The dependent variable for this research is the mathematics achievement scores of the students. Gender and Race are included as independent variables. Also included are independent variables that, according to previous research, influence mathematics achievement. Independent variables include family information such as family income and highest level of parent education. An additional socio-economic variable included in the research is the percent of students attending each student's school who qualify for free or reduced-price school lunch. The prevalence of the practice of tracking and the frequency with which teachers share information on their curriculum is also measured. Finally, the independent variables include those representing Culturally Relevant Pedagogy: Conceptions of Self and Others, Social Relations and Conceptions of Knowledge. Also, in order to determine the multiplicative effective of race with each of the three Culturally Relevant Pedagogy variables, interactive variables were developed:

Conceptions of Self and Others * Black, Social Relations * Black, Conceptions of Knowledge * Black, Conceptions of Self and Others * Hispanic, Social Relations * Hispanic and Conceptions of Knowledge * Hispanic.

The data suggests a strong relationship between mathematics and race, a significant amount of which this model does not explain. As evidenced by the fact that race is significant, there is still much to learn about the factors that affect mathematics achievement. Socioeconomic factors also have a strong relationship with mathematics achievement, with the higher levels of socioeconomic status leading to related higher levels of mathematics achievement.

For the variables representing Culturally Relevant Pedagogy, the positive relationship between Social Relations and mathematics achievement would support Ladson-Billings' theory that when teachers interact with students outside of the formal teacher/student relationship, making themselves available outside of class time, students achieve more in mathematics. The negative coefficient for Conceptions of Knowledge, while contrary to Ladson-Billings' theory, is not surprising. The pedagogy represented by this variable is the practice of not assigning grades strictly in firm performance indicators, but instead on more fluid indicators such as student effort, student participation or student improvement. Since the mathematics achievement variable in this study was based on a mathematics achievement test, it reflects a way of assigning scores that is at odds with Conceptions of Knowledge. That the Conceptions of Self and Others did not produce a statistically significant coefficient on its own, but did produce a statistically significant positive coefficient as part of an interaction variable with Hispanic and with black would indicate that there is an interaction effect between this variable and

the two race variables. These results also suggest that this pedagogy is not as important to the mathematics achievement of white students, a large portion of the sample.

Conceptions of Self and Others appears to be more important to students who are often marginalized due to race, ethnicity or socioeconomic status. These results would support Ladson-Billings' (1994, 1995a, 1995b) theory that when teachers believe that all students can succeed and when teachers try to encourage their interest in mathematics as part of everyday life and the world around them, they will achieve more in mathematics.

In addition to working to correct educational inequities through creative pedagogies and mathematics programs intended to increase mathematics achievement among low income and minority students, efforts have also been made to impact these circumstances through legislation and judicial action.

While many have identified the relationship between race and ethnicity and between socioeconomic levels and the quality of the public education experience, tackling this issue through the courts and legislation has been as complicated as trying to understand these circumstances through educational research. Early state court cases based their complaints on the differences between funding for lower and upper income students that resulted from property tax serving as the funding base for public education. Although the courts sometimes found for the plaintiffs in these cases, the resulting actions did not dependably improve the quality of public education for all. Later state court cases based their charges on the failure of the state to fulfill the education clause in it the state constitution, claiming that education promised in the state constitution was not provided equally to all citizens. The court decisions in these cases produced better results, often outlining concrete measures of good educational practices and good

educational outcomes. Some legislation has also followed suit, working to develop outcomes measures that can be used to verify that a good quality education is being provided to all citizens, regardless of their socioeconomic status. As with the work in educational research, the answers are not easy and progress is slow.

Mathematics is an important component in today's public education as mathematics skills are more necessary than before to ensure access to college and employability in today's growing technology-driven industries. Black and Hispanic and low income students have a history of lower achievement in mathematics at a statistically significant level. The consequences to Black and Hispanic and low income students of lower mathematics achievement are significant. Researchers and legislatures each are working to identify and correct the causes of this disparity in mathematics achievement.

Legislative and court activity have worked to address lower academic and mathematics achievement through examinations of public policy related to the funding of public education which has often resulted in lower funds spent on the education of students of lower socioeconomic levels, a disproportionate number of whom are black and Hispanic.

Researchers have worked to explore many hypothesis about the causes of the differences in mathematics achievement between black and Hispanic and white students. Researchers have explored range of possible causes of these differences including the effects of tracking, the effects of varying curricula, the effects of the availability of resources, varying student effort and variations in teacher practices.

This dissertation focuses on the effect of Culturally Relevant Pedagogy (Ladson-Billings, 1994, 1995a, 1995b) on the mathematics achievement of black and Hispanic

high school students. The results suggest that socioeconomic factors and race/ethnicity are strongly connected to mathematics achievement in ways that this model is not able to fully explain. However, results in this research suggest that the pedagogy of Social Relations, the Culturally Relevant Pedagogy variable suggesting that when teachers spend time with students outside of the formal teaching relationship students will achieve more, relates positively to mathematics achievement. In addition, the interaction variables exploring the relationship between race/ethnicity and each of the three Culturally Relevant Pedagogy variables, produced results worth further investigation. The interaction between Conceptions of Self and Others * Black and Conceptions of Self and Others * Hispanic each produced a positive relationship with mathematics achievement.

These results suggest that for black and Hispanic students, the teaching pedagogy characterized by the belief that all students can succeed and the belief that students need to see mathematics in their everyday life may have merit. These results are consistent with the work, reviewed in Chapter Three, of Escalante and Moses, among others. Escalante and Moses each work from the belief that all students can succeed and that it is important that students see mathematics in their everyday life. Based on the results of this research, the effects of Culturally Relevant Pedagogy (Ladson-Billings, 1994, 1995a, 1995) on mathematics achievement of black and Hispanic students merits further investigation.

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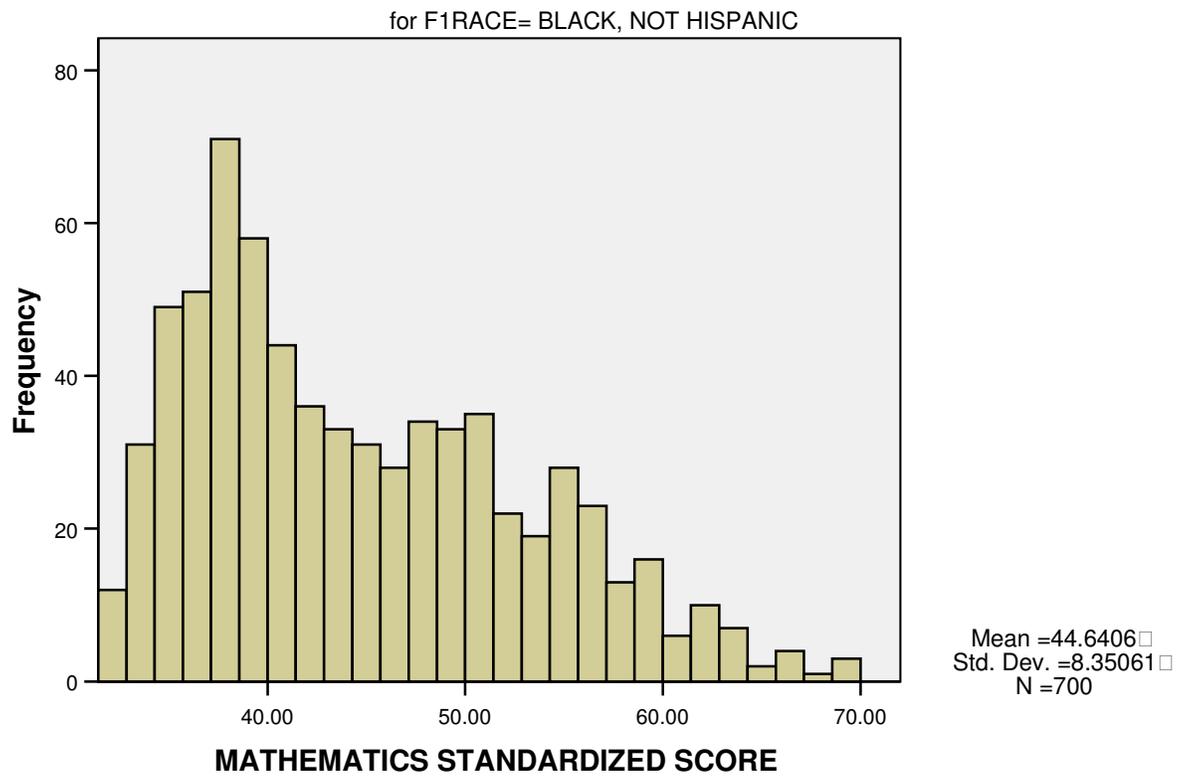
Appendix

Distribution of Culturally Relevant Pedagogy Variables by Race/Ethnicity of Student

	Social Relations (3 point scale)	Conceptions of Self & Others (4 point scale)	Conceptions of Knowledge (4 point scale)
Hispanic	Mean: 1.9449 N: 690 SD: .82935	Mean: 3.057 N: 729 SD: .59395	Mean: 2.7735 N: 758 SD: .65052
Black	Mean: 2.0146 N: 615 SD: .79991	Mean: 3.0686 N: 652 SD: .57501	Mean: 2.8956 N: 667 SD: .66686
White	Mean: 1.8944 N: 4746 SD: .78502	Mean: 2.9778 N: 5007 SD: .58841	Mean: 2.6512 N: 5077 SD: .65889

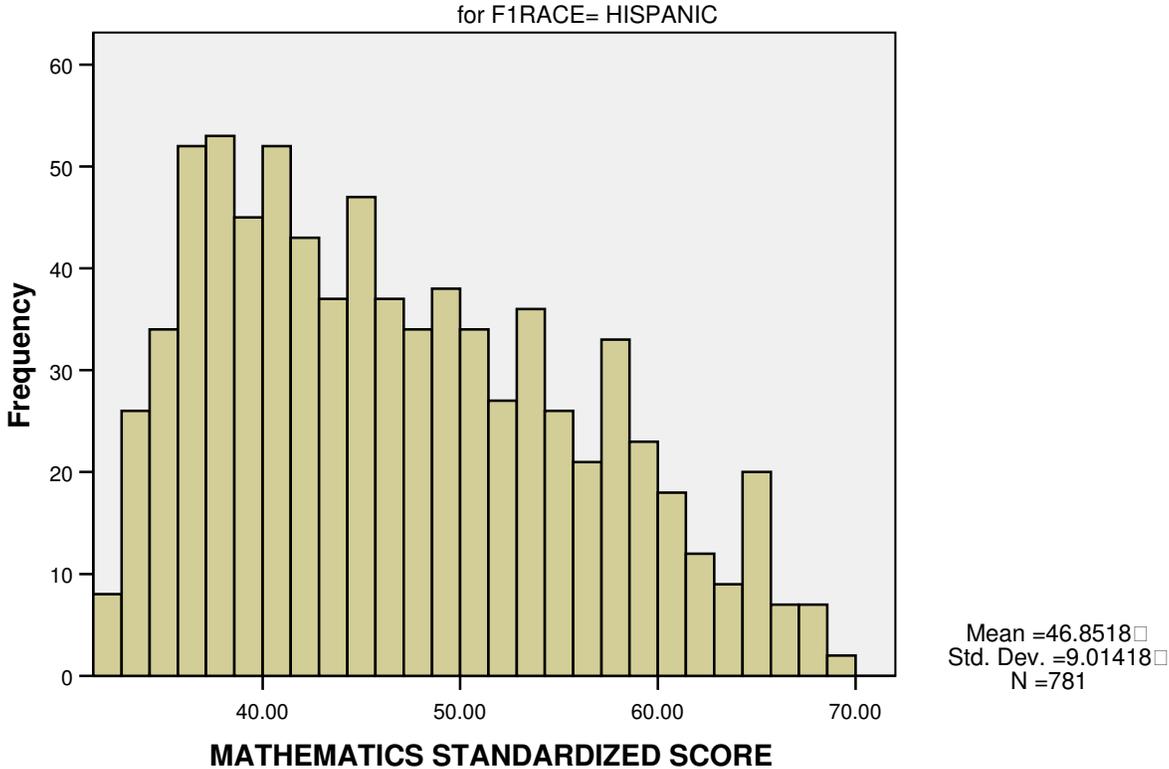
Mathematics Score Distribution – Black, Not Hispanic

Histogram



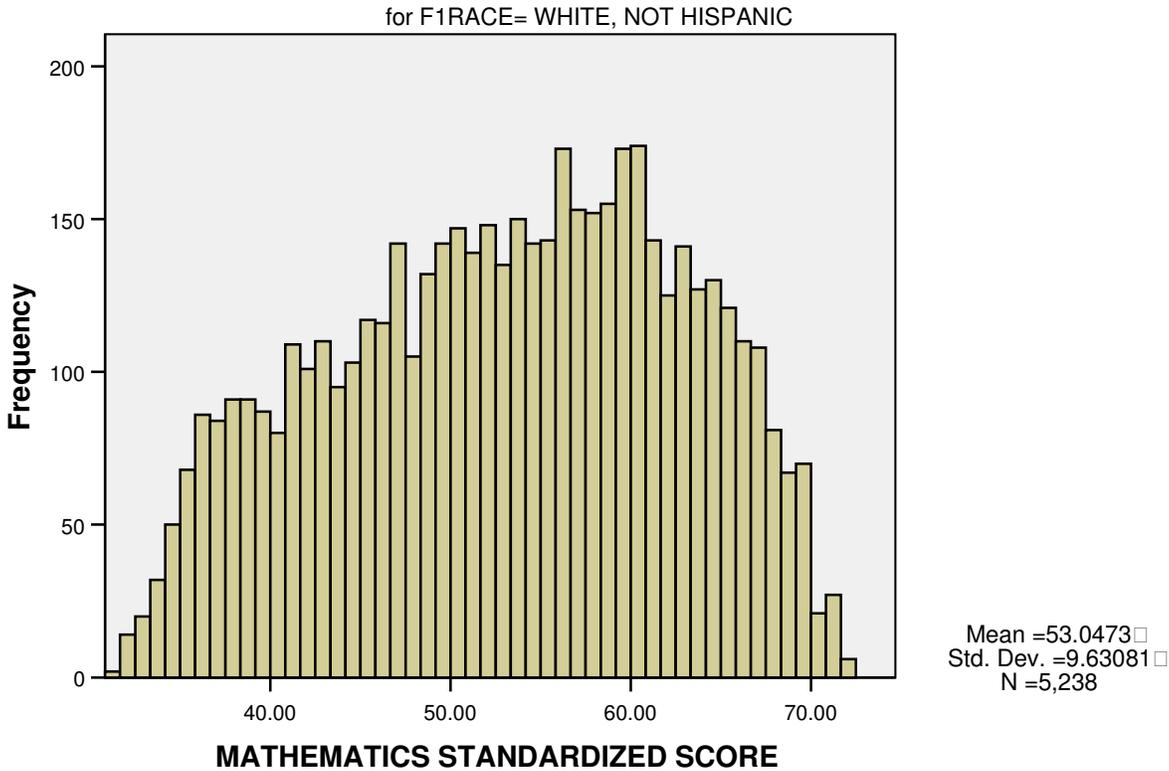
Mathematics Score Distribution, Hispanic

Histogram



Mathematics Score Distribution, White, Not Hispanic

Histogram



**NELS:88 Teacher Questionnaire Questions Used for Culturally Relevant Pedagogy
Independent Variables**

Conceptions of Self and Others

F1T2M19D/F1T6M19D

Emphasis on Interest in Mathematics

Indicate the emphasis you place on becoming interested in mathematics

- 1) None
- 2) A little
- 3) Moderate
- 4) Heavy

F1T2M19F/F1T6M19F

Emphasis on Importance of Mathematic

Indicate the emphasis you place on developing an awareness of the importance of mathematics in everyday life

- 1) None
- 2) A little
- 3) Moderate
- 4) Heavy

F1T2M19I/F1T6M19I

Emphasis on mathematics in science

Indicate the emphasis you place on the importance of mathematics in the basic and applied sciences.

- 1) None
- 2) A little
- 3) Moderate
- 4) Heavy

F1T2M19K/F1T6M19K

Emphasis on mathematics in business

Indicate the emphasis you place on learning about the application of mathematics in business and industry.

- 1) None
- 2) A little
- 3) Moderate
- 4) Heavy

Social Relations

F1T323HM/F1T723HM

Minutes spent communicating with parents.

Indicate the minutes you spent communicating with parents/in parent conference in the past week.

- 1) None
- 2) 30 minutes or less
- 3) More than 30 minutes

F1T323IM/F1T723IM

Minutes spent tutoring individual students

Indicate the number of minutes you spent tutoring individual students in the last week.

- 1) None
- 2) 30 minutes or less
- 3) More than 30 minutes

F1T323JM/F1T723JM

Minutes in academic counseling with students

Indicate the number of minutes you spent in academic counseling with students in the last week.

- 1) None
- 2) 30 minutes or less
- 3) More than 30 minutes

F1T323KM/F1T723KM

Minutes spent in personal counseling with students

Indicate the number of minutes you spent in personal counseling with students in the past week.

- 1) None
- 2) 30 minutes or less
- 3) More than 30 minutes

Conceptions of Knowledge

F1T3_24C/F1T7_24C

Importance of individual improvement in grading

Indicate the importance of individual improvement or progress over past performance in grading.

- 1) Not important
- 2) Somewhat important
- 3) Very important
- 4) Extremely important

F1T3_24D/F1T7_24D

Importance of effort in grading

Indicate the importance of effort in grading.

- 1) Not important
- 2) Somewhat important
- 3) Very important
- 4) Extremely important

F1T3_24E/F1T7_24E

Importance of class participation in grading

Indicate the importance of class participation in grading.

- 1) Not important
- 2) Somewhat important
- 3) Very important
- 4) Extremely important