African American Achievement in High School Mathematics

Everly Estes Broadway

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Approved by:

Susan N. Friel - Advisor

Barbara Day - Reader

Carol E. Malloy - Reader

Rita O’Sullivan - Reader

Charles Payne - Reader

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ABSTRACT

Everly Broadway: African American Achievement in High School Mathematics
(Under the direction of Susan N. Friel)

This research study examined the impact of one particular standards-based (Goldsmith, Mark, & Kantrov, 2000) set of high school mathematics curriculum materials, *Contemporary Mathematics in Context* (Core-Plus Mathematics Project, 1998), on the achievement of African Americans in high school mathematics. The conceptual framework for the research study builds on the curriculum model of the *Third International Mathematics and Science Study (TIMSS)* researchers (Schmidt, 1997), the research framework of the Center for the Study of Mathematics Curriculum researchers (2007) and the research of Johansson (2003; 2005; 2006). The conceptual framework includes five areas of curriculum—the *intended curriculum,* the *assessed curriculum*, the *learned curriculum*, the *implemented curriculum* and the *potentially implemented curriculum*. The research study focused on the role of the textbook in influencing the mathematics achievement of African American students in high school mathematics and compared the achievement scores and achievement levels in Algebra 1 and Algebra 2 of students who were taught using standards-based curriculum materials for high school mathematics to the scores of students who were taught using conventional curriculum materials for high school mathematics.

Results indicated that the standards-based curriculum materials made a significant positive difference in Algebra 1 achievement scores and levels for African

American students. Results indicated that the standards-based curriculum materials did not make a significant positive difference in Algebra 2 achievement scores for African American students. In both Algebra 1 and Algebra 2 results, the difference in the achievement scores of African American and other students were smaller for students using the standards-based curriculum materials than for students using conventional curriculum materials. Although the textbook is not the only factor that matters in learning mathematics, this study indicates that the choice of textbook can make an important difference in the achievement of African Americans in high school mathematics.

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CHAPTER 1: INTRODUCTION

Background

Although almost two decades have passed since the National Council of Teachers of Mathematics published the landmark document, *Curriculum and Evaluation Standards for School Mathematics* (1989), the distribution of mathematics achievement scores of African American students on many measures of mathematics achievement do not reflect a distribution similar to the population of other students (Campbell, Hombo, & Mazzeo, 1999; Tate, 2005). This persistent difference in the distribution of mathematics achievement results is perplexing and disturbing.

My experience as the Director of Mathematics K-12 in an urban school system of 32,000 students and my refusal to be satisfied with the mediocre achievement of all of the students in mathematics, particularly the African American students, served as the primary impetus to conduct this research study. I worked with principals and teacher leaders in the district to identify a strategy for improving mathematics achievement for all students in the district. In a manner that is similar to the way a state education office endorses a preferred set of textbooks to influence changes in the way mathematics is taught, I worked with the principals and teachers in the school district that I served to leverage the use of *standards-based* materials for teaching mathematics as a key strategy for improving the mathematics achievement of all students in the school district (Braun, Wang, Jenkins, & Weinbaum, 2006). The following section indicates how I identify *standards-based* mathematics materials.

Standards-Based Materials

The quest for equity and excellence in K-12 Mathematics fueled the mathematics reform movement of the late 1980s including the publication of *Curriculum and Evaluation Standards for School Mathematics* by the National Council of Teachers of Mathematics (1989). In this paper, the 1989 document will be referred to as *NCTM Standards 1989*. Also in 1989, the Mathematical Sciences Education Board (MSEB) and the National Research Council (NRC) published the landmark book, *Everybody Counts*. The publication of *Everybody Count*s along with the *NCTM Standards 1989* marked an important turning point in mathematics education toward a concentrated effort to offer challenging mathematics content to all students. *Everybody Counts* notes the changing demographics of the U.S. and documents the persistent differences in the mathematics achievement between African American students and other students. The text of *Everybody Counts* makes a persuasive argument for the urgency of reforming mathematics education to provide access to high quality mathematics education for all students.

In 2000, NCTM produced a revision of the *NCTM Standards 1989*. This new document, *Principles and Standards of School Mathematics*, noted in this paper as *PSSM 2000,* serves as a handbook for today's mathematics educators for designing and choosing appropriate classroom materials for school mathematics (National Council of Teachers of Mathematics). *PSSM 2000* begins with a simple statement about equity in mathematics: "Imagine a classroom, a school, or a school district where all students have access to high-quality, engaging mathematics instruction" (p. 3). *PSSM 2000* calls for excellent mathematics for all students.

In response to the *NCTM Standards 1989*, the National Science Foundation (NSF) funded 13 grants for writing mathematics curriculum to reflect the standards. Commercial publishers have now packaged and published these 13 programs as mathematics textbooks. The table below catalogs the program titles and publishers of these curricula (Goldsmith, et al., 2000).

Table 1. *Standards-Based Mathematics Curricula Sponsored by the National Science Foundation*

Level	**Program Title**	**Publisher**
Elementary	Everyday Mathematics	McGraw Hill
Elementary	Investigations in Number, Data, and Space	Pearson Scott Foresman
Elementary	Trailblazers	Kendall Hunt
Middle	MathScape	McGraw Hill Glencoe
Middle	Connected Mathematics	Pearson Prentice Hall
Middle	Mathematics in Context	It's About Time
Middle	MMAP	Voyager Expanded Learning
Middle	MaThematics	McDougal Littell
High	Arise	COMAP
High	Interactive Math Program	Key Curriculum Press
High	Math Connections	It's About Time
High	Contemporary Mathematics in Context (Core Plus Mathematics Project-CPMP)	McGraw Hill Glencoe
High	SIMMS Integrated Mathematics	Kendall Hunt

The five high school standards-based curricula sponsored by the NSF differ from conventional high school mathematics textbooks in the United States because they take an integrated approach to the mathematics content. Because of the integrated arrangement of mathematics content, these textbooks are sometimes called integrated mathematics books. The integrated mathematics textbooks weave together mathematics content from conventional Algebra 1, Geometry and Algebra 2 courses along with other contemporary mathematics content topics such as discrete math and probability and statistics. Generally speaking, the mathematics topics taught in the first three textbooks of an integrated (standards-based) high school mathematics program include most of the mathematics topics taught in a three year conventional program of Algebra 1, Geometry, Algebra 2. In addition to the conventional topics, the integrated (standards-based) high school textbooks also contain discrete mathematics and statistics topics.

The five high school standards-based mathematics curricula sponsored by the NSF not only differ from conventional high school mathematics textbooks with respect to content, these textbooks also differ with respect to the way topics are introduced and expected to be taught. The standards-based textbooks emphasize contexts for application of the mathematics procedures and concepts.

This research study investigates the impact of one particular standards-based set of high school mathematics curriculum materials, *Contemporary Mathematics in Context (Core-Plus Mathematics Project, 1998),* on the achievement of African Americans in high school mathematics. *Contemporary Mathematics in Context* is commonly known as the *Core Plus Mathematics Project (CPMP)*. The structure of CPMP includes a three year core of mathematics content intended for all students, plus a fourth course which is adaptable according to a student's post-high school plans (Fey & Hirsch, 2007). CPMP is published by Glencoe McGraw Hill Companies in the United States.

District Context

My position as Director of Mathematics involved leading the school district to provide professional development and technical assistance for all mathematics teachers. I met tirelessly with teachers at all grade levels to develop pacing guides and prepare instructional calendars connected to high quality classroom resources. Despite our diligent efforts to support the mathematics teachers in our district in teaching mathematics well, achievement in mathematics in our district changed very little in my first five years of service. During those years a small group of secondary mathematics teacher leaders and I participated in a three year leadership project connected to the critical issue of student performance in Algebra 1. We were not satisfied with the disproportionately lower performance of African American students than other students in our district on our state's exam for Algebra 1. We were heavily influenced by documents produced by the National Council of Teachers of Mathematics (NCTM) and we began exploring the possibility of using standards-based mathematics curriculum materials sponsored by the National Science Foundation (NSF) that were currently under production.

In 1998 the teacher leaders and I designed a systemic professional development plan that was tied directly to the implementation of standards-based materials for mathematics. Our decision to use these materials at the high school level was tied to our deep discontentment with the results on the North Carolina End of Course Test in Algebra 1 (North Carolina Department of Public Instruction, 2004a). The decision to use standards-based textbooks that looked so different from the familiar conventional textbooks in high school mathematics took courage and involved a certain amount of risk on the part of the principals and teachers involved.

We initiated the use of standards-based materials in high school mathematics during the year of textbook adoption. State textbook adoption funds allowed the district to purchase the standards-based textbooks we needed. We applied for funds from the

National Science Foundation (NSF) and received funds for a systemic, sustained program of professional development for every mathematics teacher in the district. We named our initiative *Realizing Achievement in Mathematics Performance* or *Project RAMP* (NSF Award #9819542). Our motto for our initiative was "All students are capable of learning challenging, meaningful mathematics."

At the high school level, students were offered a choice between the conventional Algebra 1 course and a course called Integrated Mathematics 1. Integrated Mathematics 1 was taught using the standards-based CPMP textbook. The teacher leaders and I spent a great amount of time with school counselors and parents introducing the format and intentions of the integrated (standards-based) mathematics program for high school students. The research documented in this paper compares the mathematics performance on state achievement tests of high school students who were taught using the conventional textbook with the mathematics performance of students who were taught using the standards-based CPMP textbook.

The context of this research study not only involves *Project RAMP*. The context also involves the federal educational legislation known as the *No Child Left Behind (NCLB)* Act (2001). The following section describes the influence of NCLB on the research study.

No Child Left Behind

The most recent reauthorization of the Elementary and Secondary Schools Act (ESEA) by the U.S. Congress has come to be known as the *No Child Left Behind (NCLB)* Act (2001). The NCLB legislation constitutes a major overhaul of the funding and accountability measures that govern public schools in the United States. Along with increased attention on attracting and keeping high quality teachers and flexibility of funding, the legislation emphasizes parent rights and holding schools to measurable standards. The centerpiece of the legislation is *Adequate Yearly Progress (AYP)*, a measure of student progress toward proficiency in Reading, Mathematics, and Science. The *AYP* measures are based on student testing results, and *NCLB* invokes a progressive set of sanctions against schools that do meet *AYP*. These sanctions include having to offer parents the choice of transferring the student to a school that did meet *AYP*, free supplemental services for students, and restructuring of the school. The *NCLB* legislation requires schools to disaggregate student achievement data into subgroups. Subgroups include ethnic subgroups, students with disabilities, students for whom English is not their first language and students who qualify for free and reduced school lunches. All sub-groups of students must meet *AYP* for a school to meet *AYP* (U.S. Department of Education, 2006)

Problem

The NCLB legislation identifies African Americans as a subgroup of students, which must make *Adequate Yearly Progress (AYP)* in reading and mathematics. The NSF standards-based curriculum materials were designed with a specific emphasis on reaching all students. Because the NSF standards-based curriculum materials are relatively new materials, there has been little research examining the high school mathematics achievement of students who are in mathematics classrooms taught primarily using standards-based materials. There is a need for investigating the mathematics performance of African American students as a subgroup of the total population who are in high school mathematics classrooms and being taught primarily using standards-based curriculum materials.

Purpose of the Study

The purpose of this study is to examine the impact of one particular standards-based set of high school mathematics curriculum materials, *Contemporary Mathematics in Context (Core-Plus Mathematics Project, 1998),* on the achievement of African Americans in high school mathematics.

Research Questions

Major Research Question

How does use of standards-based mathematics curriculum materials relate to measures of mathematics achievement for African American high school students?

Major Hypothesis

African American students who use standards-based mathematics curriculum materials will score higher on measures of Algebra 1 and Algebra 2 mathematics achievement than comparable students who do not use standards-based mathematics curriculum materials.

Sub Hypothesis 1

All students who use standards-based mathematics curriculum materials will score higher on the North Carolina End of Course (EOC) Tests in Algebra 1 and Algebra 2 than comparable students who do not use standards-based mathematics curriculum materials.

Sub Hypothesis 2

African American students who use standards-based mathematics curriculum materials will score higher on the North Carolina End of Course (EOC) Tests in Algebra 1 and Algebra 2 than comparable students who do not use standards-based mathematics curriculum materials.

Definition of Terms

African American or Black are terms that refers to students of African descent. The terms African American and Black will be used interchangeably in this study.

CPMP is an abbreviation for the Core Plus Mathematics Project, the curriculum materials that are the focus of this research study (Core-Plus Mathematics Project, 1998).

High school mathematics refers to mathematics curriculum commonly taught in grade levels 9-12. Note that high school mathematics may be used in other years of schooling.

Integrated mathematics refers to mathematics curriculum materials for grade levels 9-12 with content topics that are arranged as a unified whole rather than organized into the conventional discrete courses of Algebra I, Geometry, and Algebra II. Integrated mathematics is the term that is often used for sets of *standards-based* high school mathematics curriculum materials.

Other is a term that refers to students who are not African American.

School mathematics refers to the mathematics commonly taught in U.S. schools between kindergarten and grade 12.

Standards-based materials are mathematics curriculum materials funded by the NSF specifically to exemplify the *NCTM Standards 1989* and the *PSSM 2000* (Goldsmith, et al., 2000).

White is a term that refers to students of Caucasian descent.

CHAPTER II: LITERATURE REVIEW

Relevant literature provides a basis for the research study. Although this research study focuses on curriculum and its place in the educational system, curriculum in its many forms is situated in a larger context. This chapter begins with a discussion of relevant literature related to the broad context of educational systems in the United States. The literature related to the broad context is concentrated in four main areas--resources, vision and leadership, relationships and beliefs. After discussion of the broad context, the chapter moves to a discussion of curriculum in its many forms. The chapter concludes with a summary linking the literature to the proposed study.

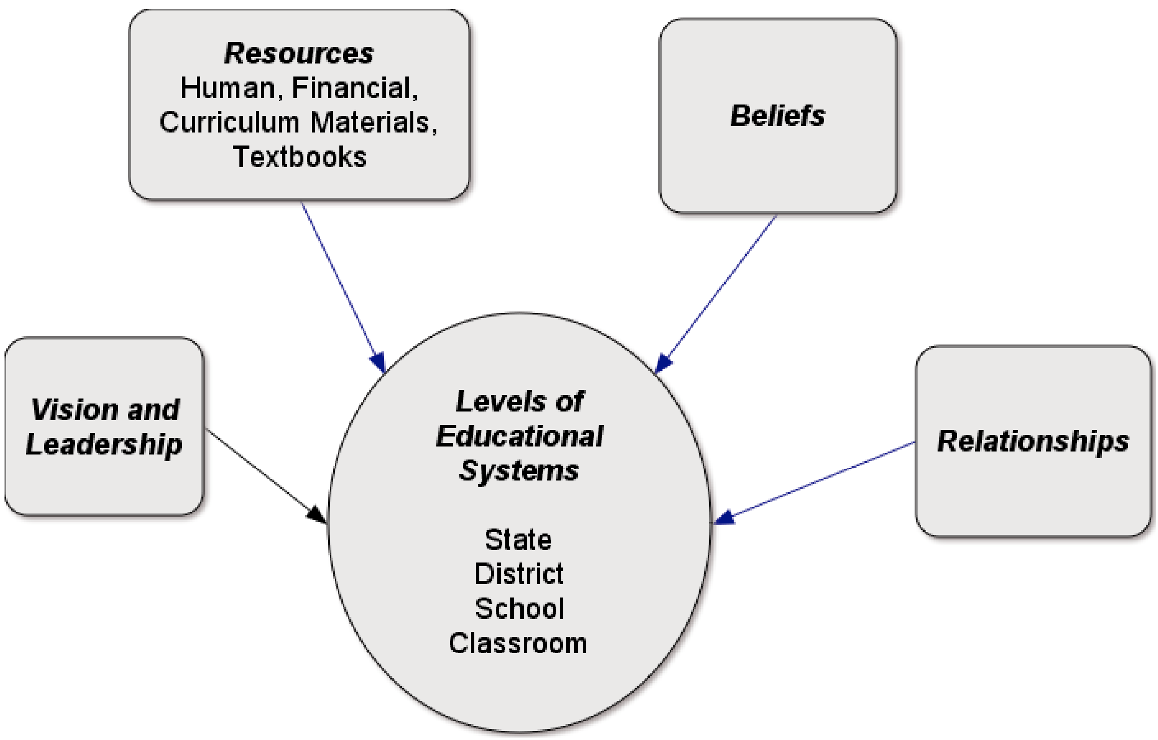
Broad Context

Although this research study focused on various aspects of curriculum, there is an important broad context detailed in the literature that must be acknowledged. The broad context involves parts of the educational system within society and the influence that the educational system and society have on mathematics achievement. Figure 1 illustrates the larger context described in the literature and potential influences on mathematics achievement.

Systems Thinking

It is important to situate the literature on curriculum into the broader context of society and schooling in America. The systems thinking model offers a way to look at the broader context of society and schooling. The systems thinking model suggests that all parts of a system are interrelated and that a change in one part of the system affects all of the other parts. Recognizing the interconnectedness of key elements of a system makes it possible to engineer change within the system (Senge, 1990, 2000, 2006). African American students in the United States primarily study mathematics in classrooms that are part of high schools that in turn are part of school systems that in turn are part of state educational systems. Key elements of these educational systems include resources, vision and leadership, relationships, and beliefs.

Figure 1 Broad contextual framework for research study



Resources

Resources at all levels of the education system may be categorized into financial resources, human resources, and curricular resources. The financial resources available at all levels of an educational system are a reflection of the power and influence of particular ideologies and persons (Allexsaht-Snider & Hart, 2001; Apple, 1992; Callan, Finney, Kirst, Usdan, & Venezia, 2006; Center on Reinventing Public Education, 2007; St. John, 2007). Although financial resources are important, few people would argue that finances are enough. Human resources are also critically important. Students interact with teachers and school administrators on a regular basis. Many research studies document teacher quality as a highly significant factor in student achievement (Berry, 2007; Braun, et al., 2006; Clotfelter, Ladd, & Vigdor, 2007; Darling-Hammond & Youngs, 2002; Greenberg, Rhodes, Ye, & Stancavage, 2004; Ingersoll, 1999; Sanders & Rivers, 1996). In addition to financial resources and human resources, curricular resources are also important. Textbooks and associated instructional materials are common tools of mathematics learning. Curricular resources play a major role in giving access to mathematics content (National Research Council, 2002; Schmidt, Wang, & McKnight, 2005).

Vision and Leadership

In addition to resources, a substantial body of research indicates that vision and leadership are an important component of an educational system. Principals influence the instructional setting and have tremendous power to promote or discourage appropriate teaching practices (Fullan, 2003; Hargreaves & Fink, 2003; Knapp, Copland, & Talber, 2003; Oliva & Pawlas, 2001). Some argue that the principal as instructional leader may be the most important factor in schools that successfully teach all students (Fullan, 2003; Oliva & Pawlas, 2001).

Relationships

The vision and leadership of instructional leaders relates to the interconnectedness or relationships of the people in the school. Relationships are another significant component of an educational system. The relationships between teachers and school administrators, teachers and parents, and teachers and students play an important role in student achievement (Wolfe, McIntosh, Steffy, & Kappa Delta Pi, 2004). Teachers and school administrators sometimes participate in structured professional learning communities which have an established protocol for studying their craft together with the goal of successfully teaching all of the students (DuFour & Eaker, 1998; Wolfe, et al., 2004).

Beliefs

Although financial, human, and curricular resources as well as instructional vision, leadership and relationships all contribute to structures that may promote or discourage achievement of African American students in mathematics, one other area of powerful influence remains–beliefs regarding who is able to learn mathematics. Although much has happened since Africans were brought to the United States on slave ships, the residue of a slave economy remains in our society. The residue includes overt racism and hidden assumptions about the intellectual abilities of people. Many of the patterns of behavior are not even questioned. It does not make sense that the achievement of African American students in mathematics continues to differ from their White peers (Martin, 2000). We must examine our practices and find ways to encourage and demand that all of our students excel in mathematics (Allexsaht-Snider & Hart, 2001; DuBois, 1935; Hilliard III, 1991; Ladson-Billings, 1997). Placement procedures and tracking in mathematics are well documented (Martin, 2004; Oakes, 1990; Oakes, Wells, Jones, & Datnow, 1997; Tate, 1997a) as well as the fact that students who do not have access to mathematics content are unlikely to demonstrate achievement in mathematics content

(2004; Tate, 2005). White teachers, in particular, must acknowledge the hidden privileges that they have in society and critically examine beliefs that may contribute to the achievement gap in mathematics between White and Black students (Bol & Berry, 2005; Martin, 2003; McIntosh, 1990; Tate, 1997b).

The literature regarding the broad context of education in the United States represented in Figure 1 and described above serves as an important reminder that curriculum does not reside in a vacuum. Key elements of the educational system, including resources, vision and leadership, relationships, and beliefs must be addressed in unlocking the potential and genius of African American students in mathematics. Recognizing the complexity of the issues involved, this research study investigated the role of one standards-based mathematics textbook, a particular form of curriculum, and its role in the mathematics achievement of African American students. The next section discusses curriculum in its many forms.

Curriculum

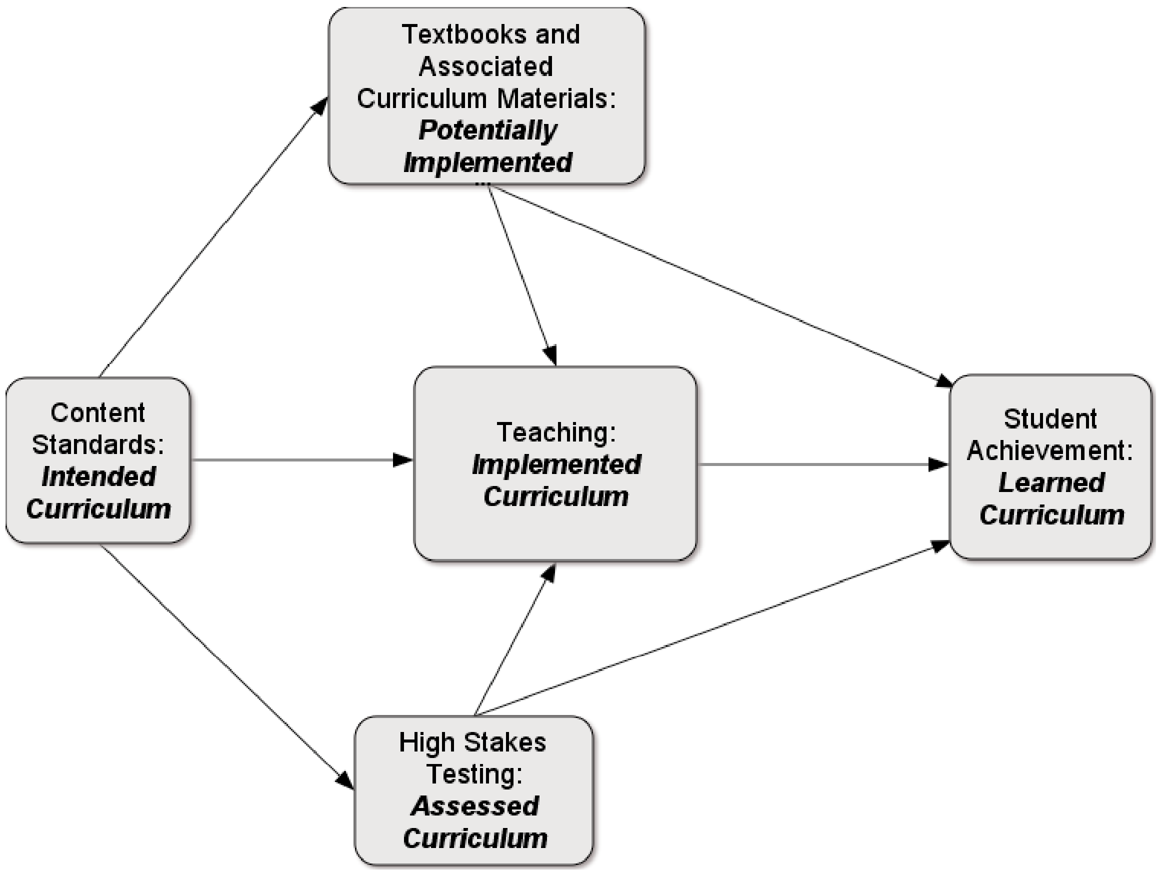
Students must have access to mathematics content to learn mathematics content. Although students may learn mathematics content in other ways, this research study restricted inquiry to the formal educational system as the primary place where students access mathematics content. The term curriculum has different meanings. Content standards from the state education agency are sometimes called curriculum. These content standards from the state level education system influence the content that is taught in mathematics classrooms. Mathematics content standards from the state level education system also influence what mathematics content is assessed on high stakes state-level tests. Ideally, mathematics content from the state's content standards aligns with the content taught in mathematics classrooms and the content tested on high stakes state-level tests. Practitioners commonly refer to such alignment as alignment of the written, taught and tested curriculum.

This research study centered on a particular feature of the educational system—the curriculum. Building on the leadership of the *Third International Mathematics and Science Study (TIMSS)* researchers (Schmidt, 1997) and following the Center for the Study of Mathematics Curriculum researchers (2007) the conceptual framework guiding the study included five areas of curriculum—the *intended curriculum,* the *assessed curriculum*, and the *learned curriculum* as well as the *implemented curriculum* and the *potentially implemented curriculum*. Figure 2 demonstrates visually the inter-relatedness of the various forms of the curriculum and identifies the mathematics content standards defined by the state level education system as the *intended curriculum*, the content tested on high stakes state-level tests as the *assessed curriculum*, the student achievement results from the high stakes state-level tests as the *learned curriculum*, the content taught in mathematics classrooms as the *implemented curriculum*, and the textbooks and associated instructional materials employed to teach the content standards as the *potentially implemented curriculum*. The next sections of the paper describe each of these facets of curriculum and related research.

Intended Curriculum

Most state educational systems in the United States define mathematics content standards, and many states then employ these content standards to construct state assessments. Due to the requirements of the *No Child Left Behind (NCLB)* Act (United States Congress, 2001), state departments of education that did not previously have grade level specificity to their mathematics content standards have now specified mathematics content standards by grade level.

Figure 2. Specific conceptual framework: Relationship between aspects of curriculum



The majority of state level mathematics standards documents refer back to the *NCTM Standards 1989* or the revised document*, PSSM 2000.* It is important to note; however, that the *NCTM Standards 1989* and *PSSM 2000* documents do not outline grade level specific content standards*.* In practice, the lists of content standards to be taught in mathematics differ substantially from state to state (Klein, et al., 2005; B. J. Reys, 2006; Schmidt, 1997; Schmidt, McKnight, Raizen, & Third International Mathematics and

Science Study, 1997). Content standards for K-12 mathematics at the state level in the education system serve as the primary beginning point for determining what mathematics will be taught and assessed in a state's K-12 schools. Following the leadership of the *Third International Mathematics and Science Study (TIMSS)* researchers (Schmidt, 1997) the conceptual framework guiding the study identifies state content standards as the *intended curriculum*.

Assessed Curriculum and Learned Curriculum

Many states have extensive high stakes assessment systems to indicate student achievement of the state's content standards. Following the leadership of the Center for the Study of Mathematics Curriculum researchers (2007), the conceptual framework guiding the research study identifies state assessments as the *assessed curriculum*. State education agencies design assessments to measure whether students have learned the *intended curriculum* articulated in the state's mathematics content standards. Following the leadership of the Center for the Study of Mathematics Curriculum researchers (2007), the conceptual framework guiding the research study identifies measures of student achievement as the *learned curriculum*.

The requirements of the *No Child Left Behind (NCLB) Act* (United States Congress, 2001) spurred states to develop or identify assessments to measure student attainment of mathematics content standards. The concept of alignment is relatively simple and grounded in instructional design theory (Dick, Carey, & Carey, 2001): set clear standards, teach content aligned with the standards, and then measure whether these standards are met with tests and assessments that align with the standards. Proponents of a system that aligns content standards and assessment assert that curriculum and testing alignment serves as the key to minimizing differentiated achievement because the alignment levels the playing field and gives all students access to the *intended curriculum* or state standards (English, 2002; English & Steffy, 2001; E. D. Hirsch, 2000; Schmoker, 1999).

Despite the promise of curriculum and testing alignment, there is reason for caution regarding the push for high stakes testing brought on by the *NCLB Act* (United States Congress, 2001). In a paper presented at the meeting of the American Educational Research Association, Shepard (2001) reviews hazards of high stakes testing. She describes misleading test scores achieved by teaching that imitates the format of the test questions as an undesirable consequence of high stakes testing. Conversations with mathematics teachers whose students are subject to high stakes testing readily admit replacing the *intended curriculum* with focused test practice in days leading up to the test (Rousseau & Powell, 2005). In this way the *assessed curriculum* influences the *intended curriculum*, sometimes a little too much.

The next two areas of the conceptual framework, *implemented curriculum* and *potentially implemented curriculum* hold central importance to the research study. The following sections describe the *implemented curriculum* and the *potentially implemented curriculum.*

Implemented Curriculum

The practice of teaching mathematics holds a central position in research concerning student achievement in mathematics. The conceptual framework indicated in Figure 2 demonstrates the importance of teaching by placing teaching at the center of the model. Teachers instruct students in *intended curriculum*, the mathematics content identified by the states' content standards. In this way teachers serve as the implementers of the curriculum. Following the leadership of the TIMSS researchers (Schmidt, 1997) the conceptual framework guiding the research study identifies the practice of teaching as the *implemented curriculum*. Several factors influence the *implemented curriculum*, including teacher quality (Ackerman, Heafner, & Bartz, 2006; Darling-Hammond, 2000; Darling-Hammond & Youngs, 2002; Greenberg, et al., 2004; Hill, Schilling, & Ball, 2004; Laczko-Kerr & Berliner, 2002), the context of teaching (Boaler, 2003; Broadway & Bowman, 2002; Haberman, 1991; Rousseau & Powell, 2005; Wenglinsky, 2002, 2004), views about teaching and learning (Boaler 1998; 2002; Bransford, Brown, Cocking, & National Research Council, 2000; Kilpatrick, Swafford, Findell, & National Research Council, 2001; Malloy, 1994; 1997; 2004; Malloy & Jones, 1998; Pesek & Kirshner, 2000; Skemp 1979;1987; Stiff & Harvey, 1988) views about the nature of mathematics (Freudenthal, 1973; Gravemeijer & Terwel, 2000; Gonzales, et al., 2000; Gonzales, et al., 2004; Halmos, 1980; Kilpatrick, et al., 2001; Lakatos, 1976; Lampter, 1990; Schoenfeld, 1987, 1992; Stein, Grover, & Henningsen, 1996; Stigler & Hiebert, 1999), decisions about problem solving in context (Aspy, Aspy, & Quimby, 1993; Charlin, 1998; Friel, 2000; Lambros, 2002; Maudsley, 1999; Moses & Cobb, 2001; Lester & Garofalo, 1982; Malloy & Jones, 1998; Schoenfeld, 1992; Silver, 1985), decisions about mathematics as a tool for democracy (Frankenstein, 1990, 1994; Gutstein, Lipman, Hernandez, & de los Reyes, 1997; Kamii, 1990; Malloy, 2002; Moses & Cobb, 2001; Payne 1997; 2003; Senk & Thompson, 2003; Skovsmose, 1994, 2005; Tate, 1994, 1995), and decisions regarding the culture of the mathematics classroom (Burns, 1998; Cobb & Nasir 2002; Frankenstein 1990; 1994; Ladson-Billings 1994;

1998a; 1998b; Malloy & Malloy, 1998; Martin 2000; Tobias, 1987; 1993). The practices of teachers in mathematics instruction have the power to create a classroom environment where all students may or may not thrive in learning mathematics. The following sections discuss the different influences on the *implemented curriculum*.

Teacher Quality

Outcries about the quality of the teaching force can be heard almost daily in the U.S. media. Features of teacher quality include: sufficient preparation for teaching, years of teaching experience, depth of content knowledge, adequacy of pedagogical content knowledge, facility with instructional practices, and participation in professional development (Ackerman, et al., 2006; Darling-Hammond, 2000; Darling-Hammond & Youngs, 2002; Greenberg, et al., 2004; Hill, et al., 2004; Laczko-Kerr & Berliner, 2002). Although the teacher quality research cited here does not focus solely on mathematics teachers, substantial evidence suggests that teacher quality influences mathematics teaching and learning as it does teaching and learning in other subject areas.

Context of Teaching

The context or community environment in which teaching takes place is an essential component of a description of the *implemented curriculum*. Haberman (1991) describes pedagogy that is often seen in urban areas as the pedagogy of poverty. Although his description does not specifically apply to mathematics nor does it specifically apply to African American students, due to the large percentage of African American students in urban areas, his insights into the typical pedagogy used in urban schools are relevant to this discussion on the achievement of African Americans in mathematics. Haberman mentions several common practices in classrooms that taken alone would not seem unusual. These practices include giving information, asking questions, giving directions, making assignments, monitoring seatwork, reviewing assignments, giving tests, reviewing tests, assigning homework, reviewing homework, settling disputes, punishing noncompliance, marking papers, and giving grades. Haberman's observation is that these teaching acts tend to exclude all others in urban schools. He calls for instructional practices that go beyond the pedagogy of poverty to include instructional practices that foster critical thinking and problem solving. The research of Wenglinksy (2002; 2004) identifies instructional practices such as teaching with a focus on higher-order thinking and teaching with hands-on learning that may disproportionately assist African American students. The findings of Wenglinksy concur with the statements by Haberman.

The influence of the high stakes testing on the climate of teaching makes it very difficult for teachers to trust standards-based curriculum materials and not resort to mechanical, repetitive test practice (Boaler, 2003; Broadway & Bowman, 2002). Research by Rousseau and Powell (2005) illustrates the influence of context or community environment on teaching standards-based mathematics. The teacher in the study who taught in a suburban school felt control over instructional choices while the teacher in the study who taught in an urban school expressed the sense of not having control over instructional choices. In particular, the teacher in the urban school expressed that superiors had indicated the necessity of conducting constant test practice in the weeks before the high stakes test.

Views about learning

The views that teachers hold about mathematical understanding contribute significantly to their instructional practices. Teaching a student how to find the slope of a line by giving the student a list of steps to follow may give the student skill enough to perform on a test; however, the student who knows the steps but also knows how changes in slope effect the graph of the line has a deeper understanding of the concept of slope. Skemp (1979; 1987) describes the practice of following mathematical procedures without deep understanding as instrumental understanding of mathematics. He contrasts instrumental understanding with relational understanding of mathematics. Relational understanding allows the learner to connect mathematical procedures to meaning and to the larger body of mathematical knowledge. Current brain research supports teaching connections of content to promote deep understanding (Bransford, Brown, Cocking, & National Research Council, 2000; Kilpatrick, Swafford, Findell, & National Research Council, 2001).

Jo Boaler (1998; 2002) conducted case studies of two schools over a three-year period. Her research methods included classroom observations, questionnaires, interviews, and quantitative assessments. Teachers at one school taught mathematics using a traditional approach while teachers at the other school taught mathematics using a more open, project-based approach. Boaler's research suggested that students in both schools demonstrated proficiency with procedures of solving mathematics problems; however, students attending the open, project-based school were more able to apply mathematical procedures to unfamiliar situations.

Pesek and Kirshner (2000) conducted a quasi-experimental research study comparing two groups of students being taught a standards-based curriculum. The researchers compared two large groups of elementary students. One group of students received instruction in the rote skill before they received instruction using the pedagogy promoted by the standards-based curriculum materials. The other group of students received only the instruction using the pedagogy promoted by the standards-based curriculum materials. On standardized achievement measures, the two groups had equal computational skills; however the "concepts only" group showed greater achievement in relational understanding. Pesek and Kirshner used the terms relational understanding (understanding what to do and why) and instrumental understanding (understanding what to do) as coined by Skemp (1977). Results of the Pesek and Kirshner study suggest that teaching for rote skill development before teaching for conceptual understanding interferes with meaningful learning in the long run. Teaching that primarily promotes instrumental understanding is ultimately inefficient and is likely to block relational understanding.

There is some evidence to suggest that honoring particular approaches to learning increases the likelihood that African American students will learn mathematics. Stiff and Harvey (1988) speak of the need for teachers to recognize that typical teaching in the United States favors middle class people of European descent. In particular, the preference of Black students to focus on problems holistically rather than in isolated pieces distinguishes them from their White peers. Stiff and Harvey refer to research describing African American students as field dependent rather than field independent. African American students tend to demand a context for making meaning in a situation.

Malloy (1994; Malloy & Jones, 1998) conducted research on problem solving approaches of African American students who were enrolled in a pre-college enrichment program for middle school students. Malloy documented the students' strategies for taking in various forms of information and synthesizing the information to solve problems as a problem solving strength of the African American students in the study. Malloy connected the use of holistic approaches in problem solving to literature regarding holistic learning preferences of African American students (Willis, 1992). In addition, Malloy (1997; 2004) suggested several strategies for teaching mathematics in a way that honors the preferences of African American students and indicates how these strategies are aligned with the *NCTM Standards 1989* and the *PSSM 2000.*

As documented by Boaler (1998, 2002), Pesek and Kirshner (2000), Stiff and Harvey (1988), and Malloy (1994, Malloy & Jones 1998), the view that a teacher holds regarding teaching and learning mathematics significantly influences student access to the mathematics content. Providing access to mathematics content is key to minimizing the differential achievement levels between African American students and other students in mathematics. Teachers who stress relational understanding and connections rather than isolated bits of procedural knowledge give their students a much better chance of accessing the mathematics content in deep and meaningful ways.

Views about mathematics

The *implemented curriculum* or the act of teaching is not only influenced by the qualifications of the teacher, the context or community environment of the instruction, and the teacher's views about teaching and learning. The teacher's views about the nature of mathematics also heavily influence instruction. Many teachers see mathematics learning as a complex code of rules and procedures rather than as a process of thinking. A teacher who views mathematics in this way views mathematics learning as the ability to perform rules and procedures. Such a teacher often spends a great deal of time on explaining and having students practice procedures until the procedures are a habit. Doing mathematics in these situations means knowing and applying the rules that are given by the teacher. In contrast, a teacher who views mathematics as a way of thinking is likely to spent significant amounts of instructional time leading students to look for patterns, make conjectures on how to solve problems, and explain their thinking. Doing mathematics in these situations means participating in the processes of mathematics, not just knowing and applying rules of mathematics (Freudenthal, 1973; Gravemeijer & Terwel, 2000; Halmos, 1980; Lakatos, 1976; Lampert, 1990; Schoenfeld, 1987, 1992; Stein, Grover, & Henningsen, 1996).

Characterizations of good mathematics teaching offer a window into how the majority of U.S. students and teachers view the nature of mathematics. Students in the U.S. are more likely to describe a good mathematics teacher as the teacher who tells them how to follow the procedures of mathematics rather than the teacher who expects them to struggle in solving problems and take responsibility for their own learning. Video-recordings of mathematics teaching taken during the Third International Mathematics and Science Study (TIMSS) reveal that eighth grade classrooms all over the U.S. are strikingly similar (Gonzales, et al., 2000; Gonzales, et al., 2004; Kilpatrick, et al., 2001; Stigler & Hiebert, 1999). Teachers in typical U.S. eighth grade mathematics classrooms explain and demonstrate procedures. Following explanation and demonstration, students practice the demonstrated procedures. Classroom observations of mathematics classrooms in the United Stated conducted by Horizon Research, Inc., reveal a similar pattern (Weiss, Pasley, Smith, Banilower, & Heck, 2003). Overwhelming in the U.S., mathematics teachers implement mathematics curriculum with the viewpoint that mathematics is a body of knowledge to be transmitted to students through explanation and practice rather than a viewpoint that mathematics is a way of thinking. The commonly held view that mathematics learning is the ability to perform rules and procedures rather than a process of thinking significantly influences the typical *implemented curriculum* in U.S. classrooms.

Decisions about Problem Solving in Context

The body of literature on problem-based learning relates to *implemented curriculum*. Problem-Based Learning (PBL) may be described as an experiential approach to teaching. The centerpiece of PBL involves two essential elements: (1) problems from a subject area that are in a meaningful context and (2) students working in small groups to design a solution to the problem, usually with a tutor who has more subject matter knowledge than the students (Aspy, Aspy, & Quimby, 1993; Charlin, 1998; Maudsley, 1999).

PBL involves presenting to students a problem wrapped in a situation or context before any external readings or study are done by the students. The problem is presented to the group, and the students determine what they need to know to solve the problem. The problem drives the learning (Barrows, 2003; Bridges & Hallinger, 1997; S. G. Mennin, Majoor, Osman, & Al Shazali, 2003; Perrenet, 2000). Because the problems drive the learning, the selection of problems in PBL is very important (Bouhuijs & Gijselaers, 1993; Strick, 2003). The PBL curriculum designers select problems which are likely to lead into particular content and cover typical situations that the professionals are likely to encounter in practice (S. G. Mennin, Pedro Majoor, Gerard Osman, Hafiz Al Shazali, 2003).

In recent years, several K-12 educators are adopting the PBL model to redesign instruction. Because it shifts the emphasis from a narrow focus on particular answers to an emphasis on working together to solve a meaningful problem, PBL gives a wider group of students a chance to contribute and succeed than is commonly the case (Friel, 2000; Lambros, 2002; Moses & Cobb, 2001). Current changes in the global marketplace demand workers who can look at complex problems and propose solutions, not workers who can simply follow step-by-step procedures (Bransford, et al., 2000; Day & Delta Kappa Gamma Society International, 1995; Edens, 2000; A. Ginsburg, Leinwand, Anstrom, & Pollock, 2005). In this way, PBL is more aligned with the viewpoint that mathematics is a way of thinking and not merely a list of procedures and skills to be memorized and practiced.

Although problem-based learning is a relatively new term and method of teaching, problem solving is not a new term to mathematics educators. While some use the term problem solving to refer to the working of simple arithmetic exercises, mathematics educators are more likely to describe a problem as a situation requiring a mathematical solution that does not have a readily recognizable answer. Problems are usually written out in words, and they may contain a diagram or other visual aids. It is possible that a problem for one learner is not a problem for another learner. Most techniques for problem solving in mathematics class relate back to the work of George Pólya, a mathematician from Stanford University who first published *How to Solve It* in

1945. Pólya described heuristics of problem solving and suggested that problem solving was a skill that could be taught. It was not an innate ability that was bestowed on a few people. In 1980, NCTM published *An Agenda for Action*, a small booklet that outlined needs in mathematics education and a proposed agenda for NCTM that focused on making problem solving the centerpiece of mathematics instruction in the U.S. In subsequent years, many U.S. mathematics educators made substantial contributions to research on problem solving in mathematics (Charles, Lester, & O'Daffer, 1987; Krulik & Reys, 1980; Lester & Garofalo, 1982; Malloy & Jones, 1998; Schoenfeld, 1992; Silver, 1985).

In addition to George Pólya, Hans Freudenthal (1973) from the Netherlands is another mathematician who has influenced the discussion on problem solving in mathematics. Freudenthal (1973) coined the term realistic mathematics education, meaning an emphasis on real-life problems connected to the reality of the children and young people that were to solve them. Freudenthal's teaching method involves giving students a realistic problem situation in context as a hook at the beginning of a lesson. This realistic problem situation captures the curiosity and interest of the student and creates a context for the mathematics lesson. The teacher's role is guiding the process by which the student constructs mathematical understanding. Realistic problem situations are chosen carefully in order that students may construct their own mathematical understanding. Freudenthal spoke of young children's "reinvention" of arithmetic through a discovery process guided by mathematical tasks provided by the teacher rather than "ready-made" mathematics being handed to students to memorize or practice (1973; Gravemeijer & Terwel, 2000; Van den Heuvel-Panhuizen, 2000). Using Skemp's terms

(1987), one might say that Freudenthal promoted relational understanding through the guided reinvention of mathematics rather than instrumental understanding brought through the "explain and practice" method of teaching.

When planning for mathematics instruction that promotes problem solving and reasoning teachers make decisions about the complexity and contextual nature of mathematical tasks to be used. Research from the QUASAR (Quantitative Understanding: Amplifying Student Achievement and Reasoning) Project, an initiative launched in 1990 to improve the mathematics education of disadvantaged middle school students, offers the mathematics education community a framework for thinking about the level of cognitive demand of problem solving tasks that are given to students. The researchers provide examples of high cognitive demand and low cognitive demand tasks. Research by the QUASAR project staff indicates that cognitively demanding mathematical tasks can provide the scaffolding necessary for students to learn to think deeply about mathematics and solve meaningful problems (Silver, Smith, & Nelson, 1995; Stein, 2000; Stein, et al., 1996). The mathematical struggle that students experience when trying to solve a complex problem promotes relational understanding of mathematics. Teachers make decisions about what mathematical tasks to use. These decisions influence the *implemented curriculum*.

Decisions about mathematics as a tool for democracy

Some researchers who focus on the achievement of African American and other non-majority students assert that having problems in context and cognitively demanding problems in mathematics teaching does not go far enough in engaging traditionally marginalized students in mathematical problem solving and reasoning. These researchers suggest that using mathematics as a tool to analyze injustices in society and prepare arguments for change in the world can serve as a powerful motivation for learning and doing mathematics (Frankenstein, 1990, 1994; Gutstein, Lipman, Hernandez, & de los Reyes, 1997; Malloy, 2002; Senk & Thompson, 2003; Skovsmose, 1994, 2005; Tate, 1994, 1995). Students may not be motivated by algebraic equations on the page in the textbook; however, when the pollution of the creek in a nearby neighborhood is the context and the algebraic equations are modeling the pollution in the creek, it becomes important to learn the algebra in order to use it as a tool for democracy.

Civil Rights historian Charles M. Payne (1997; 2003) makes the case for bringing back the freedom school model from the U.S. Civil Rights movement of the 1960s as a way to teach young African American students history and to link skills in school subjects such as mathematics and reading with advocacy for positive social change. The recent work of Moses (Moses & Cobb, 2001) of U.S. civil rights era fame connects the concept of the freedom school model and the concept of teaching mathematics for social action in the Algebra Project. The Algebra Project provides middle school students with an algebra curriculum of experiences connected to their lives. Another important facet of the Algebra Project approach is organizing communities around mathematics achievement (Kamii, 1990; Moses & Cobb, 2001). Through the Algebra Project, Moses leads a movement of Black students and other marginalized students to demand access to higher mathematics content. Moses' approach blends curriculum, pedagogy, and community support. Achievement studies from the Algebra Project indicate approaching the mathematics through context and in a way that connects to student lives seems to open the subject area to students who have often been viewed as difficult to teach algebra.

Cognitively demanding problems in the context of injustice have the possibility of giving marginalized students a reason to study mathematics beyond the minimum. Teachers have a choice whether they choose to highlight mathematics as a tool for democracy. Mathematics can become a positive tool in the hands and minds of students and teachers.

Decisions affecting the culture of the mathematics classroom

Another key aspect of the *implemented curriculum* are the decisions a teacher makes in regard to creating a climate or culture in the classroom (Malloy & Malloy, 1998). Over the years, mathematics has typically had a reputation for being a very difficult subject. Otherwise confident adults readily admit, "I was never any good at math" (Burns, 1998). These are the same people who would be very unlikely to publicly admit deficiency in reading. Somehow it seems to be acceptable in American culture to be deficient in mathematics. America's fear of mathematics is evident in the number of books and courses that are available to help young people and adults to overcome a fear of mathematics (Tobias, 1987, 1993). Fear of mathematics in American culture often passes over into somewhat of a reverence of mathematics . Some people think there is a "mathematics gene" (Devlin, 2000).

In her landmark publication, *The Dreamkeepers: Successful Teachers of African American Children*, Ladson-Billings (1994) highlights teaching methods that enable teachers to successfully teach African American children. Ladson-Billings offers a vision of culturally relevant pedagogy for African American students. To be culturally relevant, Ladson-Billings (1998b) suggests methods that include an emphasis on social relationships and asking clarifying questions so that students talk through problems and concepts. In 1997, Ladson-Billings addressed the Benjamin Banneker Leadership conference, a group of mathematics educators with a focus on teaching mathematics to African American students. The proceeding of this conference were published in 1998 by the Benjamin Banneker Association. Ladson-Billings's address to the group summarized the mathematics reform movement in relation to African American students as a group. She described the culture of mathematics in America and noted that Americans tend to fear and revere mathematics. She suggested that the success of White males and many Asian students in U.S. mathematics classrooms is directly related to the typical culture of an American mathematics classroom and the compatibility of this typical American mathematics classroom with White culture.

Ladson-Billings's (1994) work has focused on successful teachers of African American students. She believes that educators have the best opportunity for changing current African American achievement within changed notions of pedagogy. During her Banneker address in 1997 she tentatively suggested the following principles for success with African American students.

1. Students treated as competent are likely to demonstrate competence.
2. Providing instructional scaffolding for students allows them to move from what they know to what they do not know.
3. The major focus of the classroom must be instructional.
4. Real education is about extending students' thinking and abilities beyond what they already know.

5. Effective pedagogical practice involves in-depth knowledge of students as well as subject matter. (1998a, pp. 11-12)

The research of Ladson-Billings indicates that culturally relevant teaching in K-12 mathematics is desirable and possible. Ladson-Billings's suggestions mesh well with the equity language of the NCTM standards documents.

There is currently relatively little research that specifically explores the mathematics classroom as a cultural community. Authors such as Lipman (1995), Liston & Zeichner (1996) , Dilg (1999), Howard (1999), and Irvine (2003) offer insight into the multicultural facets of education, but their work is seldom reflected in the work of mathematics education researchers. Some mathematics education researchers who connect their work to multicultural facets of education are Frankenstein (1990; 1994), Martin (2000) and Cobb and Nasir (2002).

Frankenstein (1990) makes a case for incorporating views from multicultural education into mathematics teaching and broadening the view of mathematics to a subject that belongs to all people, not just those of European descent. Her work illustrates the power of connecting mathematics to real life contexts, a strategy advocated by multicultural education to make content more meaningful to students.

Martin (2000) also advocates for positive changes in classroom culture for African American students of mathematics. Martin summarizes his work in *Mathematics Success and Failure Among African-American Youth: The Roles of Sociohistorical Context, Community Forces, School Influence, and Individual Agency*. By citing numerous personal experiences and case studies, Martin advocates for making connections between culture and mathematics achievement for African American youth.

He asserts that the culture of the classroom is of utmost importance and that the gap in mathematics achievement between African American students and their White counterparts could be closed with attention to culture in the classroom.

In addition to the work of these researchers, Cobb and Nasir (2002) offer a research framework for equity in mathematics education. Cobb and Nasir suggest that the mathematics education research community look at the community of practice within a classroom, noting that there could be more than one community in the classroom. They also suggest that mathematics education researchers analyze practice within the larger community of discourse. Cobb and various groups of colleagues have long focused research on the socio-cultural nature of classrooms (Cobb & Bauersfeld, 1995; McClain & Cobb, 2001; Yackel & Cobb, 1996; Yackel, Cobb, Wood, Wheatley, & Merkel, 1990). Several researchers note the importance of providing opportunities for collaborative problem solving and discussion (Cobb, Boufi, McClain, & Whitenack, 1997; Malloy, 2004). In addition, the socio-mathematical norm of justifying mathematical thought seems particularly important in establishing an equitable classroom (Malloy, 2004; McClain & Cobb, 2001; Yackel & Cobb, 1996).

Although they address different facets of culture in the mathematics classroom, many researchers document the need for positive attention to culture in K-12 mathematics teaching. The culture of the mathematics classroom is an important facet of the *implemented curriculum*. Teacher quality, the context or environment of teaching, views about teaching and learning, views about the nature of mathematics, decisions about problem solving in context, decisions about mathematics as a tool for democracy, and decisions regarding the culture of the mathematics classroom all influence the *implemented curriculum*. Instruction or the *implemented curriculum* influences a student's learning of mathematics more than anything else.

Potentially Implemented Curriculum

Commercial publishers study a state's *intended curriculum* or content standards carefully with intentions of selling textbooks and related curriculum materials to be used in teaching the *intended curriculum.* Borrowing the term from Johannson (2003; 2005) the conceptual framework guiding the research study refers to the textbooks and related curriculum materials as the *potentially implemented curriculum*. The mathematics teacher may implement the *potentially implemented curriculum* represented by the textbook and associated curriculum materials when instructing mathematics students. Although teaching or *implemented curriculum* takes a central place in the framework for this research study, the *potentially implemented curriculum* in the form of the textbook, also serves as a major factor in student learning of mathematics.

Textbooks and associated curriculum materials play an important role in the mathematics education of students. Choices of textbooks and associated materials often determine what content is available to whom. Teachers report that they rely heavily on textbooks for information on relative importance of mathematics content and relative importance of topics. The standards-based materials supported by the NSF were an attempt to make cognitively demanding, essential mathematics content accessible to more students. This research study focuses on a particular set of NSF standards-based materials.

The textbook as a distributor of educational opportunity

Educational policy researchers describe curriculum decision making and choices about particular pedagogy as political work (M. Ginsburg, 1995; Marshall, 2002). Textbook adoption in the large states of California, Texas and Florida illustrate the political nature of textbook selection in the U.S. Textbook publishers are anxious to sell books to these states; therefore, these states with large buying power have tremendous influence over what textbooks are available to the rest of the market in the U.S. (Seely, 2003). In an effort to mobilize mathematics textbook purchasers to make research based decisions about textbook choices, proponents of standards-based curriculum materials offer suggested criteria for assisting states, districts and teachers in making thoughtful choices (Mathematics Curriculum Center, 2001; Tarr, Reys, Barker, & Billstein, 2006).

Teachers make choices about which textbook to use and about which content to select from the textbook. In this way, the teacher acts as a policy broker, enhancing or preventing access to mathematics content based on choices that are made (Cohen, Raudenbush, & Ball, 2003; Haggarty & Pepin, 2002; Schwille, et al., 1983). Researchers in the *Third International Mathematics and Science Study (TIMSS)* analyzed textbooks and curriculum documents from participating countries and documented disturbing news regarding access to mathematics content in the U.S. (Cogan, Schmidt, & Wiley, 2001; Schmidt, 1997; Valverde, Bianchi, Wolfe, Schmidt, & Houang, 2002; Valverde & Schmidt, 2000). Mathematics content as demonstrated in U.S. mathematics textbooks and curriculum documents indicates lack of focus and depth. Textbooks serve as a possible distributor of mathematics knowledge, yet students cannot access content in depth if textbooks do not contain content in depth.

Reliance on textbooks

U.S. teachers report a heavy reliance on mathematics textbooks for instruction. Surveys of students through the National Assessment for Educational Progress in mathematics indicate heavy textbook use (Grouws & Smith, 2000). Surveys of mathematics teachers through the National Survey of Science and Mathematics Education also indicate a heavy reliance on textbooks (Weiss, Banilower, McMahon, & Smith, 2001; Whittington, 2002). TIMSS research also indicates that textbooks play a significant role in the mathematics education of U.S. students (Schmidt, 2001).

Textbooks affect what content is taught

Many teachers see the mathematics textbook as the perfect “teacher helper”. They expect the textbook to serve as the authority on mathematics content. Some see the textbook personified as a familiar friend to the mathematics teacher or learner. Teachers rely on textbooks to present a blueprint or road map of the mathematics content to be taught and learned. Not only do teachers expect the textbook to help make it clear which mathematics topics should be taught, they also expect the textbook to make the relative importance of these topics clear (Doll, 2006; Floden, Porter, Schmidt, Freeman, & Schwille, 1981; Freeman & Porter, 1989; Pehkonen, 2004).

TIMSS researchers note that the textbooks of high performing countries use the textbook as a tool to organize content based on logic and coherence (Schmidt, et al., 1997). Johansson’s research involving Sweden’s mathematics textbooks indicated that the textbook is very influential even when the textbook does not align perfectly with the national curriculum (2003; 2005; 2006). A. Ginsburg et al. highlight Singapore’s mathematics textbooks as exemplary in organizing content based on logic and coherence

(A. Ginsburg, et al., 2005). From teacher helper to an organizer of content, mathematics textbooks affect what content is taught. Textbooks also affect how content is taught.

Textbooks affect how content is taught

Most mathematics teachers in the U.S. rely on textbooks and associated curriculum materials for instruction. Textbooks not only affect choices about what content gets taught but also choices about how content is taught. It is not reasonable to think that each teacher can design materials for every lesson. Textbooks may serve as appropriate tools for helping the teacher, offering suggestions about sequencing, example problems and relative importance of topics. Several researchers note the potential value of the textbook as a teacher development tool (Colloby, 2003; Friel & Bright, 1997; Remillard, 2000; Russell, 1997). In the Netherlands, textbooks have been a major tool in guiding the reform of mathematics in the spirit of Freudenthal's direction (Van den Heuvel-Panhuizen, 2000). Cohen and Ball note the potential of textbooks as a tool for influencing wide scale reform in mathematics education in the U.S. As the tool that is widely used in schools all over the U.S., textbooks could be a major influence toward mathematics teaching that makes mathematics learning accessible to all students (Ball & Cohen, 1996).

NSF Standards-Based Materials

The National Science Foundation (NSF) responded to *NCTM Standards 1989* by funding the development of textbooks and curriculum materials that would embody the philosophy and pedagogy described in the standards. Although the *NCTM Standards 1989* described the achievement gap, its unacceptability and characteristics of a mathematics curriculum that would serve all students well, the standards document did not give teachers concrete examples of a comprehensive curriculum to follow to meet the goals of the standards. Thirteen NSF curriculum projects funded to meet the *NCTM Standards 1989* provided concrete examples of an inclusive mathematics curriculum. Commercial publishers eventually packaged and published these thirteen programs authored by NSF curriculum grant recipients (Mathematics Curriculum Center, 2001). Although other programs may have some characteristics of the *NCTM Standards 1989* and the *PSSM 2000*, these thirteen comprehensive programs were field tested and developed without the pressure of the textbook market.

The development of the NSF standards-based textbooks and associated curriculum materials was a deliberate attempt to use the reliance of U.S. mathematics teachers on textbooks in a positive way to influence instruction away from mathematics proficiency for a few to mathematics proficiency for all students. The NSF standards-based materials are varied; however, in the spirit of the *NCTM Standards 1989*, all of the materials attend to issues of equity and access by making the mathematics accessible to different learners (C. R. Hirsch & National Council of Teachers of Mathematics, 2007). The political nature of choices to use the NSF standards-based materials can be seen in the reactions of different groups to the materials and the current debate in the U.S. about appropriate curriculum materials for mathematics (Fey, 1999; Jacob & Akers, 1999; R. E. Reys, 2001).

The five high school curricula sponsored by NSF differ from traditional high school mathematics textbooks in the United States because they take an integrated approach to the content. Because of this integrated approach, these textbooks are often called integrated mathematics books. The integrated mathematics textbooks weave together curriculum topics from conventional Algebra I, Geometry and Algebra II courses along with other contemporary topics such as discrete math and probability and statistics. Generally speaking the mathematics topics taught in the first three books of an integrated program include the mathematics topics taught in a conventional program with the addition of discrete mathematics and statistics topics. Integrated mathematics textbooks also emphasize contexts for application of the mathematics procedures and concepts. This research study investigates the mathematics achievement of students who were taught mathematics using a particular standards-based, integrated mathematics curriculum sponsored by the NSF, *Contemporary Mathematics in Context. Contemporary Mathematics in Context* is commonly known as the *Core Plus Mathematics Project (CPMP)*(1998). CPMP is published by Glencoe McGraw Hill Companies in the United States.

The National Council of Teachers of Mathematics (NCTM) attempted to respond to the achievement gap in mathematics by publishing the *NCTM Standards 1989* and *PSSM 2000.* The standards documents embrace equity and emphasize equitable access to mathematics content. Noting that textbooks and related curriculum materials have a strong effect on the teaching of mathematics in the U.S., the NSF developed thirteen curriculum programs as prototypes of curriculum material that embodies the *NCTM Standards 1989* (Goldsmith, et al., 2000). The NSF materials emphasize conceptual development and are intended to raise achievement in mathematics for all students. There is a need for research that explores the use of standards-based curriculum materials and mathematics achievement. The next section describes research that focuses on standards-based mathematics materials and mathematics achievement.

Standards-Based Reform in Mathematics and Mathematics Achievement

Research Featuring Standards-Based Materials

A growing number of research studies focus on the mathematics achievement of students who are learning mathematics using standards-based materials.

Riordan and Noyce

Riordan and Noyce (2001) conducted an experimental, quantitative study comparing the scores on the mathematics portion of the Massachusetts Educational Assessment Program of students who participated in a standards-based curriculum to a demographically similar group of students who participated in a traditional, "explain and practice" curriculum. The study involved elementary and middle school students. Students in standards-based programs performed significantly better on the 1999 statewide test than those from comparison schools.

Pesek and Kirshner

Pesek and Kirshner conducted a quasi-experimental research study comparing two groups of students being taught a standards-based curriculum. The researchers compared two large groups of elementary students. One group of students received instruction in the rote skill before they received instruction using the pedagogy promoted by the standards-based curriculum materials. The other group of students received only the instruction using the pedagogy promoted by the standards-based curriculum materials. On standardized achievement measures, the two groups had equal computational skills; however the "concepts only" group showed greater achievement in relational understanding. Pesek and Kirshner used the terms relational understanding

(understanding what to do and why) and instrumental understanding (understanding what to do) as coined by Skemp (1977). Results of the Pesek and Kirshner study suggest that teaching for rote skill development before teaching for conceptual understanding interferes with meaningful learning in the long run. Teaching that primarily promotes instrumental understanding is ultimately inefficient and is likely to block relational understanding.

The findings of Riordan and Noyce (2001), and Pesek & Kirshner (2000) are consistent in suggesting that although potentially implemented curriculum in the form of textbooks and materials cannot change teacher practice by itself; curriculum materials do play an important role in providing scaffolding for teachers who are trying to create a standards-based classroom environment. These findings are confirmed by Stein, Remillard, & Smith (2007) in the *Second Handbook on Research on Mathematics Teaching and Learning*.

The focus of this research study is the mathematics performance of African American students using one of the high school curricula sponsored by the NSF, *Contemporary Mathematics in Context*, commonly known as the *Core Plus Mathematics Project (CPMP)*. There are a few research studies that have featured the CPMP program.

Research Featuring the CPMP Program

Schoen, Hirsch, and Ziebarth

Schoen, Hirsch, and Ziebarth (Schoen & Hirsch, 2003; 1998) conducted a comparative study featuring the mathematics achievement of students using CPMP. The experimental group consisted of students in the CPMP program. The comparison group consisted of students using a traditional conventional program. The three instruments used in the study were the *Ability to Do Quantitative Thinking Test (ATDQT)*, a subtest of the *Iowa Test of Basic Skills (ITBS);* a version of the twelfth grade *National Assessment of Educational Progress in Mathematics for Grade 12 (NAEP Math 12)*; and a test constructed by CPMP curriculum writers.

The three-year study followed students through the CPMP curriculum and compared their performance to students who participated in the traditional curriculum. The experimental group consisted of CPMP students, and this group stayed together as a cohort through all three years of the study. The year one comparison group consisted of students in traditional mathematics classes. In year two, the comparison group included students who had been in the year one comparison group plus additional students from the traditional mathematics program who could be matched with CPMP students on the basis of demographics and prior achievement. Adding students was necessary because of the loss of students from the comparison group of year one. By the end of year three students in the traditional program classes had spread out into too many different programs and the integrity of the comparison group was compromised. The researchers decided use the national sample of students taking the *NAEP Math 12* as the comparison group in year three.

At the end of year one, the experimental group scored higher on the *ATDQT* but lower on the CPMP test in the area of computational skills. By the end of year two, the experimental group scored higher on the *ATDQT* and higher on the CPMP test, even in the area of computation. At the end of year three, the *ATDQT* and the CPMP test were not used. The researchers used the *NAEP Math 12*. The experimental group performed higher than the national average on all areas of the *NAEP Math 12*.

Huntley, Rasmussen, Villarubi, Sangtong, and Fey

Huntley, Rasmussen, Villarubi, Sangtong, and Fey (2000) conducted a quasi-experimental study to compare student performance on items in the algebra and functions strand of the curriculum. The experimental group consisted of CPMP students in year three of CPMP. The comparison group consisted of Algebra II students who had followed a three-year conventional curriculum. Both groups of students took a test consisting of items designed to measure symbolic skills and conceptual skills related to algebra and functions. The experimental group performed better on conceptual, problem-solving oriented items, including items requiring a graphing calculator. The comparison group performed better on items requiring symbolic manipulation without a calculator. Huntley's team concluded that there were trade-offs in using a NSF standards-based curriculum like CPMP.

Schoen, Cebulla, and Winsorr

Schoen, Cebulla, and Winsorr (2001) conducted a quasi-experimental study regarding student performance on college entrance exams. The experimental group consisted of students who had completed through course 4 of CPMP. The comparison group consisted of students who had completed through Pre-Calculus of a conventional curriculum sequence. The instruments used were: the mathematics sub-score of the *Scholastic Aptitude Test (SAT)*, the mathematics sub-score of the *American College Test (ACT),* and a college placement test given by a local university. The students were compared at two points: at the end of CPMP course 3 or Algebra II and the end of CPMP course 4 or Pre-Calculus. On the *SAT* sub-scores after year 3, the experimental group and the comparison group had equivalent performance. On the *SAT* sub-scores after year 4, the experimental group outscored the comparison group. On the *ACT* sub-scores after year 3 and after year 4, the experimental group outscored the comparison group. On the local mathematics placement test, given after year 4, the experimental group and the comparison group had equivalent performance in algebraic reasoning; however, the experimental group outscored the comparison group in Calculus reasoning. These results suggest that CPMP students score as well or better on typical college entrance examinations in mathematics.

Standards-Based Materials and Under-represented Students

In addition to research studies that have focused on mathematics achievement of the aggregated population (Huntley, et al., 2000; Pesek & Kirshner, 2000; Riordan & Noyce, 2001; Schoen, et al., 2001; Schoen & Hirsch, 2003; Schoen, et al., 1998; Stein, et al., 2007), a few studies have focused on the use of standards-based mathematics curriculum and pedagogy with African American students or other groups of under-represented students in mathematics (Boaler & Staples, 2008; Lane, Silver, & Wang, 1995; Lee, 1998; Lubienski, 2000; Malloy & Jones, 1998; Smith, Stiff, & Petree, 2000). None of these studies focus specifically on students using CPMP materials; however, they are included here for their specific focus on African American students or other groups of under-represented students in mathematics.

Lane, Silver, and Wang

Lane, Silver and Wang (1995), researchers in the Qualitative Understanding Amplifying Student Achievement and Reasoning (QUASAR) project, focused on the use of standards-based mathematics for teaching students in diverse communities. Researchers affiliated with QUASAR conducted a quantitative, experimental study comparing a monolingual group of students to a bilingual group of students. Instructional programs at both schools were standards-based. Results from standardized assessments indicated reform strategies in teaching mathematics are appropriate for minority populations.

Malloy

Malloy (1994; Malloy & Jones, 1998) conducted a qualitative research study with 24 African American students who were enrolled in a pre-college enrichment program for middle school students. The researchers conducted interviews and examined student work to explore problem-solving methods of the African American students. Malloy concluded that it was often the synthesis of various information and details that allowed the student to solve any given problem. The students in the study preferred a holistic approach in problem solving. Malloy documented the ability to take in various forms of information and synthesize the information to solve a problem as a strength of the students. Synthesizing information to solve problems is often a characteristic of standards-based mathematics materials.

Smith, Stiff, and Petree

Smith, Stiff, and Petree (2000) conducted a small quantitative study comparing the achievement of African American students in two high school pre-algebra classes. One class was taught using traditional teaching methods. The pedagogy in this class was largely based on review and computation using worksheets. The other class was taught using "Problem Solving Vignettes (PSVs)". The authors wrote the PSVs. The PSV classes were taught using pedagogy that reflected the influence of *PSSM 2000* and standards-based curriculum materials. The PSV classes included an emphasis on classroom discourse and on addressing complex problem situations. On standardized achievement measures, the two groups had equal computational skills; however, the PSV group scored significantly higher in conceptual dimensions of mathematics.

Boaler and Staples

Boaler and Staples (2008) conducted a longitudinal study, multiple case study of three high schools. The study employed mixed methods. The mathematics performance of students at Railside school, an urban high school with a population of primarily lower income African American and Latino students was compared to the mathematics performance of students at two other high schools with predominantly White populations and less economic diversity. The mathematics teachers at Railside school taught mathematics using a reform oriented or standards-based approach using a set of curriculum materials that Railside teachers had produced collaboratively. The teachers of the students at the comparison schools taught mathematics using traditional methods and traditional textbooks.

The research team developed tests to assess the mathematics content that was common across the three schools, and the tests were administered to the students. Teachers at all three schools agreed that the tests were accurate assessments of the mathematics content. Students at Railside school performed higher on these measures than the students at the comparison schools. These results were striking when one considered that the students at Railside came into ninth grade with a deficit in their mathematics performance. These results suggest that a teaching approach using reform oriented materials serves African American students and other marginalized students well.

Lee and Lubienski

The work of Lee (1998) questioned the methods used in standards-based instruction and their compatibility with underrepresented students. In particular, Lee asserted that authentic assessment like the assessment that is typically advocated by standards-based mathematics curricula does not have enough evidence that the approach is effective with minority students and low SES students. Lubienski (2000) expressed questions similar to Lee regarding standards-based mathematics instruction. Lubienski conducted a small qualitative study looking at students of lower SES and their responses to standards-based mathematics curriculum at the middle school level. Lubienski's methods included surveys, observations of students, student work, teaching journal entries, and daily audio recordings. She concluded that students of lower SES liked standards-based curriculum less than students of higher SES. Lubienski's results are inconsistent with the results of the QUASAR research team (Lane, et al., 1995), C.E. Malloy (1994; Malloy & Jones, 1998), Smith et al. (2000), and Boaler & Staples (2008); however, Lubienski's results resonate with Delpit's (1995) caution that reform curricula may promote a particular form of discourse, the discourse of the people in power.

Taken as a whole, existing research supports the use of standards-based mathematics curriculum and instruction. There is a need for more research that gives the picture of the whole population and also pays particular attention to underrepresented students. In particular, Tate (2005) and others have suggested that the mathematics education community further explore the performance of subgroups of students who have experienced standards-based instruction in mathematics.

Summary of Literature

The research of Tate (1997b; 2005) and others regarding K-12 African American students and mathematics achievement includes documentation of the achievement gap in mathematics and data regarding opportunity to learn mathematics. The NCTM standards documents (1989, 2000) offer a framework for mathematics curriculum and instruction that is inclusive of all students. The literature regarding African American achievement in mathematics is situated in the broad context of education in the United States. The literature regarding the broad context is concentrated in four areas—resources, vision and leadership, relationships and beliefs. The literature regarding curriculum bears the most relevance for this research study. The concept of curriculum must be unpacked to look at it carefully. Building on the leadership of the *Third International Mathematics and Science Study (TIMSS)* researchers (Schmidt, 1997) and following the Center for the Study of Mathematics Curriculum researchers (2007) the literature on curriculum was divided into five areas—the *intended curriculum,* the *assessed curriculum*, and the *learned curriculum* as well as the *implemented curriculum* and the *potentially implemented curriculum*. The *intended curriculum* (state content standards) are translated into the *potentially implemented curriculum* (textbooks and associated curriculum materials) which result in the *implemented curriculum* (teaching of mathematics). After instruction students experience the *assessed curriculum* (content of tests) and exhibit mastery of the *learned curriculum*.

Although the literature review indicated that instruction or *implemented curriculum* is a central factor in student achievement in mathematics, the literature review also indicated that textbooks and related instructional materials, described as the *potentially implemented curriculum*, also play a major role in granting access to mathematics content. Thirteen sets of textbooks and curriculum materials were sponsored by the NSF and written to embody the *NCTM Standards 1989* with the intent to offer appropriate mathematics instruction to all students. Preliminary research suggests that these curriculum materials make a positive difference in K-12 mathematics achievement. Preliminary research also suggests the need for more research relating standards-based mathematics curriculum materials and pedagogy and mathematics achievement.

Focus of the research study and Conceptual Framework

This research study investigates the mathematics achievement of African American students who were taught high school mathematics using a particular standards-based mathematics curriculum sponsored by the NSF, *Contemporary Mathematics in Context. Contemporary Mathematics in Context* is commonly known as the *Core Plus Mathematics Project (CPMP*)(1998). The research study follows the philosophy of the conceptual framework represented in Figure 2. The conceptual framework is a synthesis of the curriculum model of the *Third International Mathematics and Science Study (TIMSS)* researchers (Schmidt, 1997), the research framework of the Center for the Study of Mathematics Curriculum researchers (2007) and the research of Johansson (2003; 2005; 2006). The conceptual framework guiding the study includes five areas of curriculum—the *intended curriculum,* the *assessed curriculum*, and the *learned* *curriculum* as well as the *implemented curriculum* and the *potentially implemented curriculum*.

CHAPTER III: RESEARCH DESIGN

Design of study

The research study employs a quasi-experimental quantitative research design that involves comparison groups in a post-treatment study (Shadish, Cook, & Campbell, 2001). The treatment variable is the math type experienced by the student (conventional or standards-based). The outcome variables are the state mathematics achievement score and associated achievement level obtained by the student.

Role of the Researcher

From January 1994 until August 2005, the researcher served as the administrative staff member with responsibilities for coordination of mathematics curriculum and professional development in grade levels kindergarten through grade twelve of a medium sized, urban school system in North Carolina. From 1999-2005, the researcher also served as the Principal Investigator and Project Director of Project RAMP, Realizing Achievement in Mathematics Performance, a 3.2 million dollar Local Systemic Change Initiative (NSF Award #9819542) funded by the National Science Foundation to promote the use of standards-based mathematics materials in K-12 mathematics. The achievement data for high school mathematics, collected by Project RAMP during the spring of 2005, the final project year, serves as the data source for this research study.

Participants and Location of the Research

The research involves secondary mathematics students in a medium-sized, urban school district in the southeastern area of the United States. Founded in July 1992 from the merger of the former city and county school districts in the country, the school district is the seventh largest public school system in North Carolina. During 2004-05, the year of data collection, 30,974 students in Kindergarten through grade twelve attended school in the school district. Of those 30,974 students, 56.1% were African-American, 26.5% white, 11.8% Hispanic, and 5.6% Asian, multiracial, and Native American; 41% of the students qualified for free or reduced lunch.

Data Collection Methods

Sample Selection

During the years 2000-2005, four of the six high schools in the district allowed secondary students who had successfully completed eighth grade mathematics to choose between the conventional high school mathematics course sequence of Algebra 1, Geometry, and Algebra 2 or the standards-based mathematics course sequence of Integrated Mathematics I, II, and III (North Carolina Department of Public Instruction, 2003) as they progressed into high school mathematics for grade nine. A sample of secondary students in the school district who participated in the standards-based mathematics sequence of courses served as the treatment group for this study. A sample of students who participated in the conventional mathematics sequence of courses served as the comparison group for the study.

In North Carolina, the students in the integrated (standards-based) mathematics sequence take the same state tests in mathematics as the students in the conventional sequence; however, the timing of the tests is different. Students in the conventional sequence take the Algebra 1 EOC test at the end of Algebra 1; however, students in the integrated (standards-based) sequence take the Algebra 1 EOC test at the end of Integrated Mathematics 2. The study focused on students in grades 9-12. Accelerated students in the conventional sequence take the Algebra 1 EOC in grade 8; therefore, accelerated students in the conventional sequence were not included in the sample. In order to maximize the comparability of the groups, students who were accelerated in mathematics and began high school mathematics in either sequence before grade nine were excluded from the study.

Although researchers generally agree that teacher effects hold the greatest influence over student achievement, evidence suggests that the school that a student attends also holds great influence on a student's achievement (Konstantopoulos, 2005; Luyten, 2003; Wenglinsky, 2002). This research study analyzes secondary data from intact groups of students within the high schools in the district. There are no teachers that teach both the conventional mathematics sequence and the standards-based mathematics sequence to groups of comparable students; therefore, comparison of two groups of students with the same teacher is not possible. Consequently the best data available to the researcher suggested using comparable groups of students within schools. This study used a cluster sampling approach that compared the treatment group to the comparison group across and within each of the high schools in the sample.

Identification of the Focus Schools

During 2004-05 there were five traditional high schools housing 9th through 12th grade students and one secondary school housing 6th through 12th grade students. At four of these six schools, students were offered a choice between conventional mathematics or standards-based mathematics as they entered high school mathematics. In order for a schools' data to be used in the research study, the school needed to have a sufficient number of students in the conventional sequence and in the standards-based sequence for comparison purposes. The school housing 6^{th} through 12^{th} grade students offered only the standards-based mathematics sequence for Algebra 1 and Algebra 2, and a second high school only had three students listed as taking the conventional sequence for Algebra 1 and only four students listed as taking the standards-based sequence for Algebra 2; therefore, these two schools were eliminated from the sample. The four remaining high schools make up the sample for the research study. The term focus schools will be used to refer to these four schools. Table 2 contains information regarding the math type for non-accelerated Algebra 1 and Algebra 2 at each of the four schools in the sample. Table 3 indicates the ethnic composition of the students at the focus schools taking the Algebra 1 EOC and Algebra 2 EOC.

Data Sources and Variables

The primary sources of data for this study were the 2005 achievement test scores and achievement levels on the North Carolina End of Course (EOC) Tests in Algebra 1 and Algebra 2 (North Carolina Department of Public Instruction, 2000b). The data file available to the researcher contains information regarding student gender, grade level, limited English proficiency status and ethnicity; however, the file does not contain student names, social security numbers, birthdates, income status or other specific information that would allow the researcher to identify specific students. The file available to the researcher also contains the most recent North Carolina End of Grade (EOG) Test score in Mathematics (North Carolina Department of Public Instruction, 2006a). Data regarding the student's chosen high school mathematics sequence, conventional or standards-based, were also included in the data file.

Scale Scores

The North Carolina testing program requires that local school districts scan and score the Algebra 1 and Algebra 2 EOC tests at the district level. A software program is provided to the districts for converting the raw score on the EOCs into scale scores that are used in reporting. Calibration of the scale scores occurred during the norming year using a mean of 50 and a standard deviation of 10 for each test (North Carolina Department of Public Instruction, 2006b).

Table 2. *Students Taking the Algebra 1 and Algebra 2 EOCs by Math Type*

	Algebra 1			**Algebra 2**		
School	**Conventional**	**Standards-Based**	**Total**	**Conventional**	**Standards-Based**	**Total**
A	275	27	302	151	50	201
B	110	83	193	81	83	164
C	241	86	327	175	72	247
D	175	196	371	139	79	218
Total	801	392	1193	546	284	830

Table 3. Ethnicity of Students Taking the Algebra 1 and Algebra 2 EOCs

School	Algebra 1 EOC				Algebra 2 EOC			
	Black	White	Other	Total	Black	White	Other	Total
A								
Conventional	82%	2%	8%	91%	71%	1%	3%	75%
Standards-based	8%	0%	0%	9%	24%	0%	1%	25%
Total	90%	2%	8%	100%	95%	1%	4%	100%
B								
Conventional	27%	15%	15%	57%	19%	17%	13%	49%
Standards-based	29%	9%	5%	43%	33%	11%	7%	51%
Total	56%	24%	20%	100%	52%	28%	20%	100%
C								
Conventional	44%	21%	8%	74%	34%	33%	4%	71%
Standards-based	20%	6%	0%	26%	21%	6%	2%	29%
Total	65%	27%	9%	100%	55%	39%	6%	100%
D								
Conventional	18%	15%	14%	47%	25%	29%	10%	64%
Standards-based	32%	14%	8%	53%	21%	12%	4%	36%
Total	50%	29%	21%	100%	45%	40%	14%	100%
All Schools								
Conventional	43%	13%	11%	67%	38%	21%	7%	65%
Standards-based	22%	7%	3%	33%	24%	7%	3%	34%
Total	65%	21%	14%	100%	62%	28%	10%	100%

Totals may not equal 100% due to rounding.

Achievement Levels

The North Carolina EOC scale scores each have an associated achievement level of I, II, III, or IV. Level III and IV represent proficiency in the content area. The cut-off scores for the scale scores corresponding to particular achievement levels were set during the norming year of the test using the contrasting groups method. Teacher opinions were used in relating to student scale scores to determine the achievement levels (North Carolina Department of Public Instruction, 2006b).

The following section lists the variables used in the research study. The dependent variables were related to the achievement measures available to the researcher. The treatment variable was the type of mathematics textbook used, either standards-based or conventional. The mediating variables were included in the analysis for explanatory purposes, in the event that there were significant factors related to school membership.

Dependent Variables

1) Scale scores on the North Carolina End of Course (EOC) Tests in Algebra 1 (North Carolina Department of Public Instruction, 2000a, 2004a)
2) Achievement levels associated with scale scores on the North Carolina End of Course (EOC) Tests in Algebra 1 (North Carolina Department of Public Instruction, 2007a)
3) Scale Scores on the North Carolina End of Course (EOC) Tests in Algebra 2 (North Carolina Department of Public Instruction, 2000a, 2004b)
4) Achievement levels associated with scale scores on the North Carolina End of Course (EOC) Tests in Algebra 2 (North Carolina Department of Public Instruction, 2007b)

Treatment Variable

Math Type: conventional or integrated (*standards-based*)

Mediating Variables

1) Ethnicity: Black, Hispanic, White, Other (Manise, Blank, Dardine, & Council of Chief State School Officers, 2001)
2) Grade Algebra 1: Grade level when taking the Algebra 1 EOC test
3) Grade Algebra 2: Grade level when taking the Algebra 2 EOC test
4) School Algebra 1: School attended when taking the Algebra 1 EOC test
5) School Algebra 2: School attended when taking the Algebra 2 EOC test

Data Analysis Methods

The researcher processed the data using the SPSS statistical software package. Analysis involved descriptive and inferential statistics. Regarding performance of all students, the first analysis compared the means of the Algebra 1 and Algebra 2 EOC achievement scores across and within schools. An independent-samples *t* test was used to compare the scores of students who participated in the standards-based high school mathematics curriculum to the scores of students who participated in a conventional high school mathematics curriculum.

The second analysis regarding the performance of all students compared the ratios by groups of students who scored at particular achievement levels on the Algebra 1 and Algebra 2 EOCs across and within schools. A two-sample chi square test was conducted to determine whether the differences in the ratios of students falling below an achievement level cut-off were statistically significant.

After the two analyses were completed for all students, the same two analyses were completed for African American students.

Timeline

Spring 2005	EOC data and related demographic data were collected by the school district
Summer 2008	Obtained permission from the school district to use the data without identifying markers for the research study
Summer 2008	Identified treatment groups and comparison groups
Fall 2008	Conducted Analyses

Significance of the Study

There is a persistent achievement gap between White students and students of color in mathematics (Tate, 1997b, 2005). The standards of the National Council of Teachers of Mathematics (1989; 2000) promote standards for mathematics curriculum that intend to make mathematics accessible to all students. The National Science Foundation funded thirteen curriculum development projects to serve as prototypes of standards-based, inclusive mathematics curricula. One of these thirteen projects was used in the school district during 2004-05 as an alternative high school mathematics curriculum to the conventional mathematics curriculum of Algebra 1, Geometry, Algebra 2. This research study contributes to the research base regarding standards-based mathematics curriculum and its effectiveness, particularly with African American students.

CHAPTER IV: RESULTS

Introduction

The results consist of four analyses to examine the statistical relationships between mathematics sequence, conventional or standards-based, and measures of student achievement. The researcher processed the data using the SPSS statistical software package. Analysis involved descriptive and inferential statistics. The first analysis compared the means of Algebra 1 and Algebra 2 EOC scale scores for all students across and within schools, and the second analysis compared the ratios of all students who scored at particular achievement levels on the Algebra 1 and Algebra 2 EOCs across and within schools. After completing the two analyses for all students, the same two analyses were repeated for African American students across and within schools.

All students

The first and second analyses were designed to address sub hypothesis 1: All students who use standards-based mathematics curriculum materials will score higher on the North Carolina End of Course (EOC) Tests in Algebra 1 and Algebra 2 than comparable students who do not use standards-based mathematics curriculum materials.

Algebra 1 and Algebra 2 Scale Scores

All students

The sample for Algebra 1 included all non-accelerated students at each of the four focus schools who took the 2005 administration of the Algebra 1 EOC. The sample for

Algebra 2 included all non-accelerated students at each of the four focus schools who took the 2005 administration of the Algebra 2 EOC. Table 4 indicates the mean Algebra 1 and Algebra 2 EOC scale scores and standard deviations by math type for these groups.

Table 4. *Mean Algebra 1 and Algebra 2 EOC Scale Scores and Standard Deviations by Math Type for All Students*

	Algebra 1			**Algebra 2**		
Math Type	**n**	**M**	**SD**	**n**	**M**	**SD**
Conventional	801	54.6	8.00	546	59.0	8.53
Standards-Based	392	57.8	7.20	284	56.3	7.07

An independent-samples *t* test was conducted for all students in the sample for Algebra 1 to evaluate the hypothesis that students who use standards-based mathematics curriculum materials will score higher on the North Carolina End of Course (EOC) Tests in Algebra 1 than comparable students who do not use standards-based mathematics curriculum materials. The test was significant in favor of the research hypothesis, $t(1191)= 6.67$, $p<.001$. As a group, students using standards-based mathematics curriculum materials scored higher on the Algebra 1 EOC (M= 57.8, SD= 7.20) than students using conventional curriculum materials (M= 54.6, SD= 8.00). An independent-samples *t* test was conducted for all students in the sample to evaluate the hypothesis that all students who use standards-based mathematics curriculum materials will score higher on the Algebra 2 EOC than comparable students who do not use standards-based mathematics curriculum materials. The test was significant, $t(828)= -4.46$, $p<.001$ in opposition to the research hypothesis. As indicated in table 4, Algebra 2 students using conventional mathematics curriculum materials scored higher on the Algebra 2 EOC than students using standards-based materials.

All students by focus school

The next comparisons of mean Algebra 1 and Algebra 2 EOC scores involved comparisons within the focus schools. Table 5 indicates the mean Algebra 1 EOC scale scores and standard deviation by math type for all students by focus school.

Table 5. *Mean Algebra 1 EOC Scale Scores and Standard Deviations by Math Type for All Students by School*

School **Math Type**	**n**	**M**	**SD**	***t***	***df***	***p***
A						
Conventional	275	52.9	6.83			
Standards-Based	27	58.7	7.37	4.19*	300	.000
B						
Conventional	110	51.6	7.98			
Standards-Based	83	57.1	6.75	5.04*	191	.000
C						
Conventional	241	56.0	8.35			
Standards-Based	86	55.0	6.43	-0.960	325	.338
D						
Conventional	175	57.2	8.11			
Standards-Based	196	59.1	7.36	2.47*	369	.014

**significant at $\alpha \leq .05$*

An independent-samples *t* test was conducted for each focus school to evaluate the hypothesis that students who use standards-based mathematics curriculum materials will score higher on the North Carolina End of Course (EOC) Test in Algebra 1 than comparable students who do not use standards-based mathematics curriculum materials. The test was significant for schools A, B, and D in favor of the research hypothesis. At school C, the results were very close together and students using conventional mathematics curriculum materials scored higher on the Algebra 1 EOC than students using standards-based curriculum materials; however, the results of the *t* test for school C indicated that the differences in the means were not statistically significant.

After comparisons were completed for Algebra 1 EOC scores, comparisons were made for Algebra 2 EOC scores. Table 6 indicates the mean Algebra 2 EOC scale scores and standard deviations by math type for all students by focus school.

An independent-samples *t* test was conducted for each focus school to evaluate the hypothesis that students who use standards-based mathematics curriculum materials will score higher on the North Carolina End of Course (EOC) Test in Algebra 2 than comparable students who do not use standards-based mathematics curriculum materials. The test was significant for schools B and C against the research hypothesis. The results at school A favored the research hypothesis; however, the results of the *t* test for school A indicated that the differences in the means were not statistically significant. At school D, the results were against the research hypothesis; however, the results of the *t* test for school D indicated that the differences in the means were not statistically significant.

Table 6. *Mean Algebra 2 EOC Scale Scores and Standard Deviations by Math Type for All Students by School*

School **Math Type**	**n**	**M**	**SD**	***t***	***df***	***p***
A						
Conventional	151	54.2	6.57			
Standards-Based	50	54.3	7.00	.136	199	.892
B						
Conventional	81	60.5	8.91			
Standards-Based	83	56.6	7.54	-3.06*	162	.003
C						
Conventional	175	60.9	7.88			
Standards-Based	72	54.9	6.84	-5.61*	245	.000
D						
Conventional	139	60.8	9.04			
Standards-Based	79	58.6	6.21	-1.92	216	.057

**significant at $\alpha \leq .05$*

Algebra 1 and Algebra 2 Achievement Levels

The second analysis regarding the performance of all students compared the ratios by groups of students who scored at particular achievement levels on the Algebra 1 and Algebra 2 EOCs across and within schools. A two-sample chi square test was conducted to determine whether the differences in the ratios of students falling below the achievement level III cut-off were statistically significant. Tables 7 and 8 indicate the results of the chi square test for all students in Algebra 1 and Algebra 2 respectively.

Table 7. *Mean Algebra 1 EOC Scale Scores, Standard Deviations and Percentage Level III or Above by Math Type for All Students*

Math Type	**n**	**M**	**SD**	**Percentage Level III or Above**	χ^2	***p***
Conventional	801	54.6	8.00	49.9		
Standards-Based	392	57.8	7.20	69.6	50.1*	.000

**significant at $\alpha \leq .05$*

Table 8. *Mean Algebra 2 EOC Scale Scores, Standard Deviations and Percentage Level III or Above by Math Type for All Students*

Math Type	**n**	**M**	**SD**	**Percentage Level III or Above**	χ^2	***p***
Conventional	546	59.0	8.53	57.1		
Standards-Based	284	56.3	7.07	44.7	11.5*	.001

**significant at $\alpha \leq .05$*

All students

When using level III as a cut-off for all students in the Algebra 1 sample, 47.9% of the students using conventional materials scored a level III while 69.6% of the students using standards-based materials scored at level III, $\chi^2(1,N=1193)=50.1$, $p<.001$. When using level III as a cut-off for all students in the Algebra 2 sample, 57.1% of the students using conventional materials scored a level III while 44.7% of the students using standards-based materials scored at level III, $\chi^2(1,N=830)=11.6$, $p<.01$. Both of these results, Algebra 1 in favor of the research hypothesis and Algebra 2 against the research hypothesis are significant at $\alpha \leq .05$.

All students by focus school

The next comparisons of achievement levels in Algebra 1 and Algebra 2 involved comparisons within the focus schools. A two-sample chi square test was conducted for each focus school to determine whether the differences in the ratios of students falling below the achievement level III cut-off were statistically significant. Tables 9 and 10 indicate the results of the chi square test for all students in Algebra 1 and Algebra 2 respectively.

Table 9. *Mean Algebra 1 EOC Scale Scores, Standard Deviations and Percentage Level III or Above by Math Type for All Students by School*

School and Math Type	n	M	SD	Percentage Level III or Above	χ^2	p
A						
Conventional	275	52.9	6.83	36.7		
Standards-Based	27	58.7	7.37	77.8	17.2*	.000
B						
Conventional	110	51.6	7.98	35.5		
Standards-Based	83	57.1	6.75	65.1	16.6*	.000
C						
Conventional	241	56.0	8.35	58.1		
Standards-Based	86	55.0	6.43	57.0	0.032	.857
D						
Conventional	175	57.2	8.11	59.4		
Standards-Based	196	59.1	7.36	76.0	11.7*	.001

**significant at $\alpha \leq .05$*

The results for Algebra 1 at three out of the four focus schools, schools A, B, and D favored the research hypothesis and were statistically significant. The result at school C was against the research hypothesis; however, the result was not statistically significant. The results for Algebra 2 at three out of the four focus schools, schools B, C, and D, were against the research hypothesis; however, the results at only two of those schools, schools B and C, were statistically significant. The result for Algebra 2 at school A favored the research hypothesis; however, the result was not statistically significant.

Table 10. *Mean Algebra 2 EOC Scale Scores, Standard Deviations and Percentage Level III or Above by Math Type for All Students by School*

School and Math Type	**n**	**M**	**SD**	**Percentage Level III or Above**	χ^2	***p***
A						
Conventional	151	54.2	6.57	33.8	0.001	.977
Standards-Based	50	54.3	7.00	34.0		
B						
Conventional	81	60.5	8.91	65.4	6.41*	.011
Standards-Based	83	56.6	6.75	45.8		
C						
Conventional	175	60.9	7.88	69.7	25.9*	.000
Standards-Based	72	54.9	6.84	34.7		
D						
Conventional	139	60.8	9.04	61.9		
Standards-Based	79	58.6	6.21	59.5	.120	.729

*significant at $\alpha \leq .05$

African American Students

The third and fourth analyses mirror the first and second analyses and were designed to address sub hypothesis 2: All African American students who use standards-based mathematics curriculum materials will score higher on the North Carolina End of Course (EOC) Tests in Algebra 1 and Algebra 2 than comparable students who do not use *standards-based* mathematics curriculum materials.

Algebra 1 and Algebra 2 Scale Scores

All African American students

The sample for Algebra 1 included all non-accelerated, African American students at each of the four focus schools who took the 2005 administration of the Algebra 1 EOC. The sample for Algebra 2 included all non-accelerated, African

American students at each of the four focus schools who took the 2005 administration of the Algebra 2 EOC. Table 11 indicates the mean Algebra 1 and Algebra 2 EOC scale scores and standard deviations by math type for these groups.

Table 11. *Mean Algebra 1 and Algebra 2 EOC Scale Scores and Standard Deviations by Math Type for All African American Students*

	Algebra 1			**Algebra 2**		
Math Type	**n**	**M**	**SD**	**n**	**M**	**SD**
Conventional	511	53.4	7.50	312	56.6	7.84
Standards-Based	265	56.8	6.60	199	54.9	6.60

An independent-samples *t* test was conducted for all African American students in the sample for Algebra 1 to evaluate the hypothesis that African American students who use standards-based mathematics curriculum materials will score higher on the North Carolina End of Course (EOC) Tests in Algebra 1 than comparable students who do not use standards-based mathematics curriculum materials. The test was significant in favor of the research hypothesis, $t(774)= 6.16$, $p<.001$. As a group, African American students using standards-based mathematics curriculum materials scored higher on the Algebra 1 EOC ($M= 56.8$, $SD= 6.60$) than students using conventional curriculum materials ($M= 53.4$, $SD= 7.50$). An independent-samples *t* test was conducted for all students in the sample to evaluate the hypothesis that all African American students who use *standards-based* mathematics curriculum materials will score higher on the Algebra 2 EOC than comparable students who do not use standards-based mathematics curriculum materials. The test was significant, $t(509)= -2.63$, $p<.01$ in opposition to the research hypothesis. As indicated in table 11, African American Algebra 2 students using conventional mathematics curriculum materials scored higher on the Algebra 2 EOC than African American students using standards-based materials.

African American students by focus school

The next comparisons of mean Algebra 1 and Algebra 2 EOC scores involved comparisons within the focus schools. Table 12 indicates the mean Algebra 1 EOC scale scores and standard deviation by math type for all African American students by focus school.

Table 12. *Mean Algebra 1 EOC Scale Scores and Standard Deviations by Math Type for All African American Students by School*

School **Math Type**	**n**	**M**	**SD**	***t***	***df***	***p***
A						
Conventional	246	52.9	6.79			
Standards-Based	25	58.1	7.31	3.61*	269	.000
B						
Conventional	52	49.8	7.68			
Standards-Based	56	56.8	6.30	5.18*	106	.000
C						
Conventional	145	54.4	7.90			
Standards-Based	66	54.0	6.08	- 0.345	209	.731
D						
Conventional	68	55.7	7.86			
Standards-Based	118	58.0	6.48	2.15*	184	.033

*significant at $\alpha \leq .05$

An independent-samples *t* test was conducted for each focus school to evaluate the hypothesis that African American students who use standards-based mathematics curriculum materials will score higher on the North Carolina End of Course (EOC) Test in Algebra 1 than comparable students who do not use standards-based mathematics curriculum materials. The test was significant for schools A, B, and D in favor of the research hypothesis. At school C, African American students using conventional mathematics curriculum materials scored higher on the Algebra 1 EOC than African American students using standards-based curriculum materials by only .4 points, and the results of the *t* test for school C indicated that this difference was not statistically significant.

After comparisons were completed for Algebra 1 EOC scores, comparisons were made for Algebra 2 EOC scores. Table 13 indicates the mean Algebra 2 EOC scale scores and standard deviations by math type for African American students by focus school.

An independent-samples *t* test was conducted for each focus school to evaluate the hypothesis that African American students who use standards-based mathematics curriculum materials will score higher on the North Carolina End of Course (EOC) Test in Algebra 2 than comparable students who do not use standards-based mathematics curriculum materials. The test was significant for schools B and C against the research hypothesis. The results at schools A and D were also against the research hypothesis; however, the results of the *t* tests for these schools indicated that the differences in the means were not statistically significant.

Table 13. *Mean Algebra 2 EOC Scale Scores and Standard Deviations by Math Type for African American Students by School*

School **Math Type**	**n**	**M**	**SD**	***t***	***df***	***p***
A						
Conventional	143	54.2	6.65			
Standards-Based	48	54.0	6.87	-0.144	189	.886
B						
Conventional	31	58.9	7.95			
Standards-Based	54	55.1	6.30	-2.44*	83	.017
C						
Conventional	84	58.5	7.41			
Standards-Based	52	53.3	6.48	-4.16*	134	.000
D						
Conventional	54	58.8	9.54			
Standards-Based	45	57.2	6.28	-0.958	97	.341

*significant at $\alpha \leq .05$

Algebra 1 and Algebra 2 Achievement Levels

The second analysis regarding the performance of all African American students compared the ratios by groups of students who scored at or above achievement level III on the Algebra 1 and Algebra 2 EOCs across and within schools. A two-sample chi square test was conducted to determine whether the differences in the ratios of students falling below the achievement level III cut-off were statistically significant. Tables 14 and 15 indicate the results of the chi square test for all African American students in Algebra 1 and Algebra 2 respectively.

Table 14. *Mean Algebra 1 EOC Scale Scores, Standard Deviations and Percentage Level III or Above by Math Type for All African American Students*

Math Type	**n**	**M**	**SD**	**Percentage Level III or Above**	χ^2	***p***
Conventional	511	53.4	7.50	42.3		
Standards-Based	265	56.8	6.60	65.7	38.2*	.000

**significant at α ≤ .05*

Table 15. *Mean Algebra 2 EOC Scale Scores, Standard Deviations and Percentage Level III or Above by Math Type for All African American Students*

Math Type	**n**	**M**	**SD**	**Percentage Level III or Above**	χ^2	***p***
Conventional	312	56.6	7.84	48.4		
Standards-Based	199	54.9	6.60	36.7	6.77*	.009

**significant at α ≤ .05*

All African American students

When using level III as a cut-off for all students in the Algebra 1 sample, 42.3% of the African American students using conventional materials scored a level III while 65.7% of the students using standards-based materials scored at level III, $\chi^2(1,N=774)=6.16$, $p<.001$. When using level III as a cut-off for all students in the Algebra 2 sample, 56.6% of the students using conventional materials scored a level III while 54.9% of the students using standards-based materials scored at level III, $\chi^2(1,N=509)=-2.63$, $p<.01$. Both of these results, Algebra 1 in favor of the research hypothesis and Algebra 2 against the research hypothesis are significant at $\alpha \le .05$.

All African American students by focus school

The next comparisons of achievement levels in Algebra 1 and Algebra 2 involved comparisons within the focus schools. A two-sample chi square test was conducted for each focus school to determine whether the differences in the ratios of African American students falling below the achievement level III cut-off were statistically significant. Tables 16 and 17 indicate the results of the chi square test for all African American students in Algebra 1 and Algebra 2 respectively.

Table 16. *Mean Algebra 1 EOC Scale Scores, Standard Deviations and Percentage Level III or Above by Math Type for African American Students by School*

School and Math Type	**n**	**M**	**SD**	**Percentage Level III or Above**	χ^2	***p***
A						
Conventional	246	52.9	6.79	37.0		
Standards-Based	25	58.1	7.31	76.0	14.3*	.000
B						
Conventional	52	49.8	7.68	25.0		
Standards-Based	56	56.8	6.30	62.5	15.4*	.000
C						
Conventional	145	54.4	7.90	51.7		
Standards-Based	66	54.0	6.08	51.5	0.001	.978
D						
Conventional	68	55.7	7.86	54.4		
Standards-Based	118	58.0	6.48	72.9	6.57*	.010

**significant at* $\alpha \le .05$

Table 17. *Mean Algebra 2 EOC Scale Scores, Standard Deviations and Percentage Level III or Above by Math Type for African American Students by School*

School Math Type	n	M	SD	Percentage Level III or Above	χ^2	*p*
A						
Conventional	143	54.2	6.65	33.6		
Standards-Based	48	54.0	6.87	31.2	0.087	.768
B						
Conventional	31	58.9	7.95	64.5		
Standards-Based	54	55.1	6.30	40.7	4.45*	.035
C						
Conventional	84	58.5	7.41	61.9		
Standards-Based	52	53.3	6.48	25.0	17.5*	.000
D						
Conventional	54	58.8	9.54	57.4		
Standards-Based	45	57.2	6.28	51.1	0.392	.531

**significant at $\alpha \leq .05$*

The results for African American students in Algebra 1 at three out of the four focus schools, schools A, B, and D favored the research hypothesis and were statistically significant. The results for school C were slightly against the research hypothesis; however, they were not statistically significant. The results for Algebra 2 at all four focus schools were against the research hypothesis; however, the results at only two of those schools, schools B and C, were statistically significant.

Summary

Four analyses were conducted. The first two analyses involved comparisons of Algebra 1 and Algebra 2 EOC scale scores and associated achievement levels for all students. The second two analyses repeated the first two analyses with a focus on African American students rather than all students. Chapter 5 includes a discussion of the results.

CHAPTER V: SUMMARY OF RESULTS AND DISCUSSION

Research Hypothesis

The research study focused on one major hypothesis and two sub hypotheses.

Major Hypothesis

African American students who use standards-based mathematics curriculum materials will score higher on measures of Algebra 1 and Algebra 2 mathematics achievement than comparable students who do not use standards-based mathematics curriculum materials.

Sub Hypothesis 1

All students who use standards-based mathematics curriculum materials will score higher on the North Carolina End of Course (EOC) Tests in Algebra 1 and Algebra 2 than comparable students who do not use standards-based mathematics curriculum materials.

Sub Hypothesis 2

African American students who use standards-based mathematics curriculum materials will score higher on the North Carolina End of Course (EOC) Tests in Algebra 1 and Algebra 2 than comparable students who do not use standards-based mathematics curriculum materials.

Analyses and Results

Four analyses were conducted. The first two analyses involved comparisons of Algebra 1 and Algebra 2 EOC scale scores and associated achievement levels for all students. The second two analyses repeated the first two analyses with a focus on African American students rather than all students.

All Students

Regarding performance of all students, the first analysis compared the means of the Algebra 1 and Algebra 2 EOC scale scores across and within schools. An independent-samples *t* test was used to compare the scores of students who participated in the standards-based high school mathematics curriculum to the scores of students who participated in a conventional high school mathematics curriculum. Results of t tests yielded statistically significant differences in favor of the research hypothesis for all Algebra 1 EOC participants as a group. Significant differences in favor of the research hypothesis were also found for all Algebra 1 EOC participants at three of the four focus high schools. Results of t tests yielded statistically significant differences against the research hypothesis for all Algebra 2 EOC participants as a group. Significant differences against the research hypothesis were also found for all Algebra 2 EOC participants at two of the four focus high schools.

The second analysis involved comparisons of Algebra 1 and Algebra 2 EOC levels for all students. In Algebra 1, the comparison yielded significant results in favor of the research hypothesis with 69.6% of the students in the *standards-based* sequence scoring a Level III or higher on the EOC while 49.9% of the students in the conventional sequence scored a Level III or higher on the EOC. In three out of the four focus schools, the comparisons favored the research hypothesis. Results of chi square tests of statistical independence indicated that the differences in favor of the hypothesis at these three schools were significant while the difference against the research hypothesis at the fourth school was not significant.

The comparison of Algebra 2 levels for all students yielded a significant result against the research hypothesis with 57.1% of the students in the conventional sequence scoring a Level III score or above compared to 44.7% of the students in the standards-based sequence scoring a Level III score or above. In three out of the four comparisons of the focus schools, the results were against the research hypothesis. Results of chi square tests of statistical independence indicated that differences were significant in two of these three comparisons which were against the research hypothesis but not significant in the other two comparisons, including the one comparison in favor of the research hypothesis.

African American Students

Regarding performance of African American students, the first analysis compared the means of the Algebra 1 and Algebra 2 EOC scale scores across and within schools. An independent-samples *t* test was used to compare the scores of African American students who participated in the standards-based high school mathematics curriculum to the scores of African American students who participated in a conventional high school mathematics curriculum. Results of t tests yielded statistically significant differences in favor of the research hypothesis for all African American Algebra 1 students as a group. Significant differences in favor of the research hypothesis were also found for all African American Algebra 1 students at three of the four focus high schools. The results at the fourth focus school indicated a negligible difference in means that was not statistically significant.

Results of t tests yielded statistically significant differences against the research hypothesis for all African American Algebra 2 students as a group. Significant differences against the research hypothesis were also found for all African American Algebra 2 students at two of the four focus high schools.

The second analysis with respect to African American students involved comparisons of Algebra 1 and Algebra 2 EOC levels for all students. In Algebra 1, the comparison yielded significant results in favor of the research hypothesis with 65.7% of the students in the standards-based sequence scoring a Level III or higher on the EOC while 42.3% of the students in the conventional sequence scored a Level III or higher on the EOC. In three out of the four focus schools, the comparisons favored the research hypothesis. Results of chi square tests of statistical independence indicated that the differences in favor of the hypothesis at these three schools were significant while the difference against the research hypothesis at the fourth school was not significant.

The comparison of Algebra 2 levels for all African American students yielded a significant result against the research hypothesis with 48.4% of the students in the conventional sequence scoring a Level III score or above compared to 36.7% of the students in the standards-based sequence scoring a Level III score or above. In all four comparisons of the focus schools, the results were against the research hypothesis. Results of chi square tests of statistical independence indicated that differences were significant in two of these four comparisons.

Findings

The clear major finding of the study is that African American students who use standards-based mathematics curriculum materials score higher on measures of Algebra 1 mathematics achievement than comparable students who do not use *standards-based* mathematics curriculum materials. The finding regarding the performance of African American students who use standards-based mathematics curriculum materials on measures of Algebra 2 is unclear; however, evidence from this study is against the hypothesis that African American students who use standards-based mathematics curriculum materials will score higher on measures of Algebra 2 mathematics achievement than comparable students who do not use standards-based mathematics curriculum materials. Further study is needed to explore the effects of standards-based mathematics curriculum materials on the mathematics achievement of African American students.

African American Achievement on the Algebra 1 EOC

The overwhelming results in favor of using the standards-based CPMP textbook to teach the content measured on the North Carolina EOC in Algebra 1 to African American students warrant further attention. In her 2004 NCTM yearbook chapter entitled “Equity in Mathematics Education is About Access,” Malloy outlines practices that are likely to include more students in mathematics. She makes explicit connections between the learning preferences of students and the recommendations of NCTM as outlined in the *PSSM 2000*.

The intended curriculum in the form of the standards-based CPMP instructional materials aligns with the suggestions outlined by Malloy (2004). The standards-based CPMP textbook features a very strong emphasis on conceptual development of mathematics content as recommended by Malloy. The standards-based CPMP textbook carefully structured to guide students through reasoning about the mathematics content. This approach is very different than conventional mathematics textbooks that typically take more of an "explain and practice" approach. The standards-based CPMP textbook guides students through a structured set of questions that compose investigations. The standards-based CPMP materials contain fewer problems than conventional materials, and these problems typically take longer to complete than problems in conventional high school mathematics textbooks. Students in CPMP classes spend a great deal of time discussing the mathematics and writing about their reasoning. All of these practices favor a conceptual development of the mathematics content as described in Malloy's work (2004).

Another feature of the standards-based CPMP materials is the common use of collaborative classwork in a cooperative approach to learning mathematics (Core Plus Mathematics Project, 2008; Davidson, 1990). Although individual students may use the standards-based CPMP materials during mathematics instruction, most CPMP teachers follow the recommendations of the CPMP authors and use structured groups or pairs in teaching with the CPMP materials. A teaching approach that expects students to collaborate and learn as a mathematical community resonates with Malloy's description of the recommendations of practices that will give more students access to mathematics (2004).

African American Achievement on the Algebra 2 EOC

The discrepancy between the findings for Algebra 1 achievement and Algebra 2 achievement are perplexing. Possible explanations for the discrepancy are differing retention rates between conventional and integrated programs, misalignment between the state test and the integrated curriculum materials, and teaching practices of year three teachers in the standards-based program. Each of these possible explanations will be explored.

During the year of this research study, the graduation requirements of the North Carolina Department of Public Instruction included 4 possible courses of study for graduation (North Carolina Department of Public Instruction, 2008). One of the courses of study was specialized for severely handicapped students, and these students would not be completing the conventional or the standards-based sequence of mathematics courses. The other three courses of study all required Algebra 1 or its integrated equivalent for graduation from high school. Only one of these courses of study, the "College/University Preparation" course of study, required Algebra 2 or its integrated equivalent for graduation from high school.

Because of the structure of the graduation requirements for North Carolina students, it is reasonable to assume that all students were in the pool for the comparison of Algebra 1 EOC results. It is unlikely, however, that all students were in the pool for the comparison of Algebra 2 EOC results. Although the retention rate for students taking the conventional Algebra 2 course compared to the retention rate for students taking the Integrated Mathematics 3 course is not available, anecdotal evidence suggests that the conventional sequence lost more students than the standards-based sequence by year three of the program. This difference in retention rates of students may have made the group of standards-based mathematics students less comparable to the group of conventional mathematics students by the end of year three of the program when the achievement results from the Algebra 2 EOC were compared. The conventional group would have contained more students who had typically been successful in college preparatory mathematics, and this may have influenced Algebra 2 results.

Another possible reason for the discrepancy in the Algebra 1 and Algebra 2 findings may be that the content and types of questions on the Algebra 1 EOC are more aligned with the standards-based mathematics curriculum materials than the content and types of questions on the Algebra 2 EOC. An informal analysis of the goals and objectives of the *North Carolina Standard Course of Study for Algebra 2* indicates a much heavier emphasis on symbolic manipulation that the goals and objectives of the *North Carolina Standard Course of Study for Algebra 1* (North Carolina Department of Public Instruction, 2003). Although the research of Huntley et al. (2000) did not involve North Carolina students, Huntley et al.'s research involved a comparison of Algebra 2 students and third year CPMP students. Huntley et al.'s study was able to differentiate among performances each student on different types of assessment items. The research of Huntley's team suggested that the standards-based CPMP students performed better on conceptual, problem-solving oriented items, including items that required a graphing calculator, while the conventional Algebra 2 students in the study performed better on items requiring symbolic manipulation without a calculator. Huntley's team concluded that there were trade-offs to be considered when using a NSF standards-based curriculum like CPMP. Although the students who use standards-based materials may score better on conceptual, problem-solving oriented items, they are likely to not score as well on items requiring symbolic manipulation. The difference noted by Huntley' team may have influenced the results of the research study described in this paper.

The third possible reason for a discrepancy in the Algebra 1 and Algebra 2 results may be the teaching practices of the teachers using the standards-based CPMP textbook. The first edition of the CPMP textbook, the one used by participants in this study, indicates in the overview that the conceptual basis of the mathematics is emphasized in courses one to three while there is more symbolic emphasis in course four (Core Plus Mathematics Project, 2008). The fact that symbolic procedures are not solidified until course four even though students in this research study took the Algebra 2 EOC at the end of course three along with the findings of Huntley's team may be relevant in interpreting the Algebra 2 results of the research described in this paper. Further analysis of the alignment of the North Carolina Algebra 2 EOC and the standards-based CPMP textbook is needed to clarify these results and the results of other studies that may use the North Carolina End of Course tests (North Carolina Department of Public Instruction, 2006b) as measures of student achievement in comparing conventional and standards-based materials.

Achievement Gap

Another major finding of this study is that although African American students score lower than all students on measures of Algebra 1 and Algebra 2 mathematics achievement when using either conventional or standards-based materials, the differences between the percentage of students who score proficient on measures of Algebra 1 and Algebra 2 mathematics achievement are reduced for students using standards-based mathematics materials than for students using conventional mathematics materials. After running the statistics to answer the major question of this research study regarding use of standards-based mathematics curriculum materials and measures of mathematics achievement for African American high school students, I was perplexed by the strong positive results for standards-based materials in regard to Algebra 1 and the negative results for standards-based materials in regard to Algebra 2. As I explored reasons for the discrepancy, I became interested in exploring the differences between the achievement of African American students and the achievement of all students within the conventional program and within the standards-based program. Table 18 indicates that the mathematics performance of African American students differs less from the mathematics performance of all students when the African American students use standards-based mathematics materials. In regard to Algebra 1, the achievement levels of African American students using conventional materials differed from the achievement levels of all students by 7.6% while the achievement levels of African American students using standards-based materials differed from the achievement levels of all students by 3.9%. In regard to Algebra 2, the achievement levels of African American students using conventional materials differed from the achievement levels of all students by 8.7% while the achievement levels of African American students using standards-based materials differed from the achievement levels of all students by 8.0%. This finding is significant in light of the focus on achievement gaps in mathematics in North Carolina (Darity, Castellino, Tyson, Cobb, & McMillen, 2001).

Table 18. *Comparison of Proficiency of African American Students to All Students by Math Type*

	Algebra 1 EOC		Algebra 2 EOC	
	Conventional	*Standards-Based*	Conventional	*Standards-Based*
All Students	49.9%	69.6%	57.1%	44.7%
African American Students	42.3%	65.7%	48.4%	36.7%
Difference	-7.6%	-3.9%	-8.7%	-8.0%

Summary of Findings

Major findings of this research study are related to African American use of standards-based materials in mathematics. In this research study, African American students who used standards-based mathematics curriculum materials scored higher on measures of Algebra 1 mathematics achievement than comparable students who did not use standards-based mathematics curriculum materials. The results for Algebra 1 were strong. Evidence from this study strongly favors the hypothesis that African American students who use standards-based mathematics curriculum materials will score higher on measures of Algebra 1 mathematics achievement than comparable students who do not use standards-based mathematics curriculum materials. Results for Algebra 2 were not strong; however, evidence from this study is against the hypothesis that African American students who use standards-based mathematics curriculum materials will score higher on measures of Algebra 2 mathematics achievement than comparable students who do not use standards-based mathematics curriculum materials. A third finding related to the achievement gap in both Algebra 1 and Algebra 2. The mathematics performance of African American students differs less from the mathematics performance of all students when the African American students use standards-based mathematics materials. This finding is true for Algebra 1 and for Algebra 2. The next section describes the limitations of the study.

Limitations of the Study

There are limitations of the research study. The first limitation is that the study is a quasi-experimental research study rather than an experimental research study. Students in the treatment group made a choice to participate in the standards-based curriculum used in the integrated mathematics courses. The students were not randomly assigned as in an experimental research study. The primary threat to the validity of the results of this study is a selection threat. In order to minimize the selection threat, strong efforts were made to select comparison groups that matched the treatment groups as closely as possible. All the students in the study were from the same school system. All eligible students in a school were sorted into either the treatment group or the comparison group for their school. Schools that did not have a conventional mathematics program as well as a standards-based mathematics program were not included as a focus school for the study. Students accelerated in mathematics were not included in the study. These efforts matched the intact groups as much as possible. As discussed earlier in this chapter, the treatment and comparison groups for Algebra 1 were likely to be more closely aligned than the treatment and comparison groups for Algebra 2 because all students in North Carolina are required to take the EOC in Algebra 1, and the group of Algebra 1 participants is larger than the group of Algebra 2 participants. All students in North Carolina are not required to take Algebra 2. The treatment groups and comparison groups for Algebra 2 were much smaller than the groups for Algebra 1.

Another limitation of the study is that the research is tied to particular measures of student achievement for Algebra 1 and Algebra 2. The use of the North Carolina End of

Course tests as the achievement measures for the research study somewhat ties the results to one state, North Carolina (North Carolina Department of Public Instruction, 2004a, 2004b). However, informal comparisons of the North Carolina EOCs to sample test questions and content standards from other states indicate that North Carolina's measures are comparable to those of other states in such a way that differences do not jeopardize the ability to generalize the results of this study.

Another limitation of the study was the study's restriction to one geographic region of the United States. The focus of the study on the mathematics performance of African American students demanded that the schools involved in the study have a significant number of African American students. In this regard, the location was ideal for the study; however, this study's results must be combined with the results from other locations in the United States to fully answer the research questions.

Finally, a limitation of the study was its lack of data regarding the implementation of the standards-based curriculum in the classroom. The National Research Council suggests a multi-faceted approach to measuring curricular effectiveness, including studies of the fidelity of implementation of the materials (Confrey, Stohl, & National Research Council, 2004). This research study was limited to the learned curriculum as measured by mathematics achievement tests in North Carolina. The results were not qualified by data regarding the implemented curriculum. Put another way, the quality of the teaching of the standards-based mathematics materials was not measured as a part of this study. The researcher minimized this limitation by conducting the study in a school district in its fifth year of implementation of the standards-based curriculum materials. As part of project RAMP (NSF Award #9819542), the school district's local systemic change project in mathematics, the district's mathematics teachers had been involved in extensive professional development regarding the teaching of the standards-based CPMP materials. The next section makes suggestions for further research.

Suggestions for Further Research

This research study involved high school students in one school district in the Southeastern United States. Subsequent research studies may add to this study by conducting research studies similar to this study in multiple locations throughout the United States and looking at results across geographical areas.

This research study was confined to one year's performance data. Subsequent research studies may add to this study by conducting research studies related to this study with multiple measures of mathematics achievement over time. Being able to compare the same student's performances on the North Carolina End of Course Tests in Algebra 1 and Algebra 2 (North Carolina Department of Public Instruction, 2004a, 2004b) would allow richer comparisons of student performance than this study allowed. Longitudinal data would allow a comparison of retention data for the conventional sequence versus the retention data for the standards-based sequence.

This research study was confined to on one particular set of performance measures, the North Carolina End of Course Tests in Algebra 1 and Algebra 2 (North Carolina Department of Public Instruction, 2004a, 2004b). Subsequent research studies may add to this study by conducting research studies similar to this study using multiple measures of mathematics achievement, including measures of mathematics achievement aligned to the standards-based curriculum materials that test performance in areas not typically taught in a conventional curriculum.

This research study analyzed secondary data from intact groups of students within the high schools in the district. Subsequent research studies may add to this study by matching individual students within each school on the basis of prior achievement scores, ethnicity and other relevant factors. Matching individual students may give the research more sensitivity to the effect of the standards-based materials.

This research study did not consider teacher related variables and the quality of implementation of the standards-based CPMP curriculum materials. Chapter 2 documented the centrality of the implemented curriculum. Research indicates several variables related to teacher implementation of standards-based mathematics curriculum materials that make a difference in student achievement (Schoen, Finn, Cebulla, & Fi, 2003). The variables from the study include participation in professional development specific to implementation of the curriculum, collaboration with other teachers, less use of direct teacher presentation teaching methods and other teacher implementation variables. The Schoen study and numerous studies mentioned in Chapter 2 under Implemented Curriculum indicate that teaching practices have a primary influence on student achievement. Subsequent research studies may add to this study by adding a qualitative research component to the study. Adding data regarding the quality and fidelity of the implementation of the standards-based mathematics materials in relation to the achievement scores associated with the standards-based mathematics materials would enhance the study.

Final Remarks

This study focused on the performance of African American students using the standards-based CPMP mathematics curriculum. The participants in the study were from one school district that offered some classes using the standards-based CPMP curriculum materials for four years. Teachers of CPMP participated in extensive professional development for teaching CPMP, including summer institutes and study groups during the school year. Results clearly indicated that the standards-based CPMP curriculum materials (the potentially implemented curriculum) made an important difference in Algebra 1 achievement scores for African American students. Results for Algebra 2 scores were against the standards-based curriculum; although these results were not as clear. In both Algebra 1 and Algebra 2 results, the achievement gap between African American students and all students was smaller for students using the standards-based CPMP curriculum materials than for students using conventional curriculum materials. Although the textbook is not the only factor that matters in learning mathematics, this study indicates that the textbook choice can make an important difference in the learned curriculum and student achievement. Given the reliance of high school mathematics teachers on mathematics textbooks during instruction, the choice of the mathematics textbook can make major strides in improving mathematics education for African American students. The researcher hopes that this study will contribute to the body of research regarding African American achievement in mathematics and the significant role mathematics curriculum materials can play in that achievement.

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