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Benjamin Lewis  
*Virginia Commonwealth University*

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AN ANALYSIS OF MATHEMATICS ACHIEVEMENT DISPARITIES BETWEEN  
BLACK AND WHITE STUDENTS AND SOCIOECONOMICALLY  
DISADVANTAGED AND ADVANTAGED STUDENTS ACROSS CONTENT  
STRANDS BY ELEMENTARY AND MIDDLE SCHOOL LEVEL IN A DIVERSE  
VIRGINIA SCHOOL DISTRICT

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of  
Philosophy at Virginia Commonwealth University

by

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## **Abstract**

### **AN ANALYSIS OF MATHEMATICS ACHIEVEMENT DISPARITIES BETWEEN BLACK AND WHITE STUDENTS AND SOCIOECONOMICALLY DISADVANTAGED AND ADVANTAGED STUDENTS ACROSS CONTENT STRANDS BY ELEMENTARY AND MIDDLE SCHOOL LEVEL IN A DIVERSE VIRGINIA SCHOOL DISTRICT**

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A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at Virginia Commonwealth University

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Student achievement gaps between Black and White students, and socioeconomically disadvantaged and advantaged students, have been observed and formally documented since the National Assessment of Educational Progress (NAEP) began in the 1970s. In particular, the mathematics achievement gap between these historically disadvantaged populations has been a phenomenon that, in spite of improvements, has nevertheless remained persistent for decades. This study sought to identify and derive additional information about the mathematics achievement gap between Black students and White students, and socioeconomically disadvantaged and advantaged students, by elementary and middle school level in a Virginia

school district over three consecutive school years. Overall student performance on the Virginia Mathematics Standards of Learning (SOL) assessment was examined and achievement gaps were reported. In addition to overall mathematics achievement, this study also sought to detect specific mathematic conceptual areas in which Black and White students, and socioeconomically disadvantaged and advantaged students, were significantly disparate. Factorial Analysis of Covariance (ANCOVA) and Factorial Multivariate Analysis of Covariance (MANCOVA) were used to identify statistically significant differences between the subgroups in assessment scores reflecting overall mathematics achievement, and student achievement in five conceptual “content strands.” Interactions between student race, socioeconomic status, and school level were also examined. Effect sizes were calculated to indicate any practical significance corresponding to statistical significance noted. For overall mathematics performance, results indicated the continued presence of an achievement gap between Black and White students, and socioeconomically disadvantaged and advantaged students, for each year examined. Interaction was noted between race and socioeconomic status, and race and school level. For mathematics performance along the content strands, results indicated the presence of an achievement gap between Black and White students, and socioeconomically disadvantaged and advantaged students, in every conceptual area for each year analyzed. Interaction was indicated between race and socioeconomic status in all but one content strand during one school year. Consistent interaction was also observed between race and school level in two content strands. No significant effect size was indicated for overall or strand-based mathematics achievement differences, demonstrating limited practical significance. Implications for practice, limitations, and suggestions for future research are discussed.

## **Chapter 1**

### **Introduction**

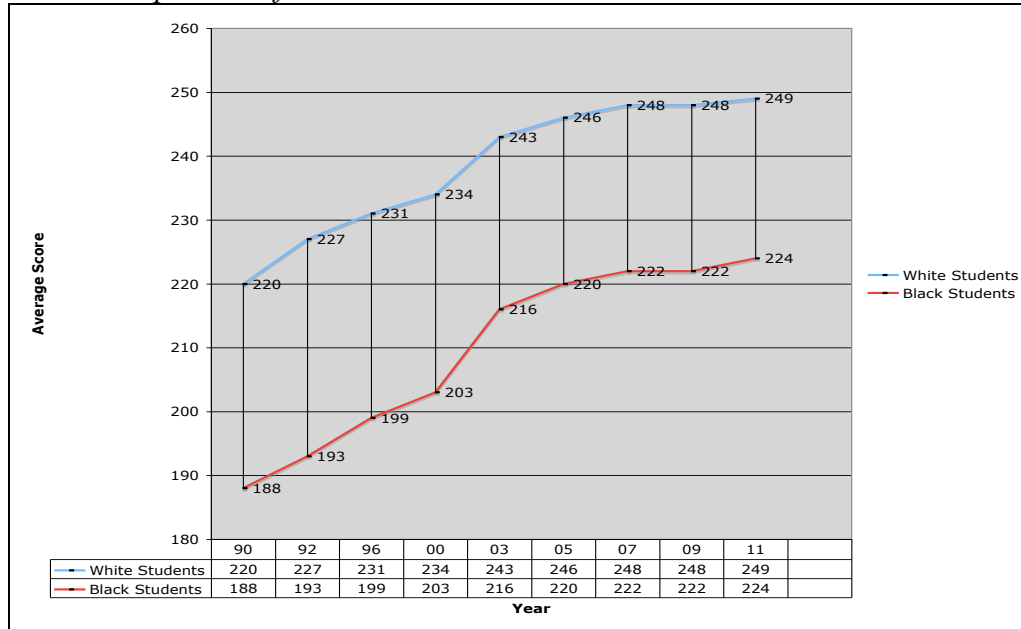
Within the last 10-15 years, there has been increased political attention and emphasis placed on the establishment of standards and accountability in the American public education system. Legislation at the federal level has reflected recent sentiments that schools in the nation must undergo comprehensive reform to improve the quality of schooling and educational opportunity for all students. The enactment of the No Child Left Behind Act of 2001 (P.L. 107-110) mandates that states measure student achievement on local standardized tests, and report results by gender, ethnicity, socioeconomic status (SES), and disability status (NCLB, 2001) in an effort to “ensure that students of all races, all abilities, and all ages receive the education they need and deserve” (USDOE, 2002). It is an established phenomenon that disparities in academic achievement exist between White and Black students in the United States, particularly in the area of mathematics performance (NCES, 2011; Brown-Jeffy, 2009; USDOE, 2008; Harris & Herrington, 2006). Low SES is also confirmed as a significant risk factor for decreased academic readiness skills and performance in our country (NCES, 2011; Faitar, 2011; Milne & Plourde, 2006; Vail, 2004) and internationally (Chiu, 2010). Race and socioeconomic status have a strong interaction with academic achievement, to the degree that the educational gaps associated with them have been described as “pervasive, profound, and persistent” (Braun, Wang, Jenkins, & Weinbaum, 2006) and significant for educational outcomes (Magnuson & Duncan, 2006). National mathematics achievement data reflect these disparities.

In 2011, the National Assessment of Education Progress (NAEP) reported updated mathematics achievement data for U.S. students in grades 4 and 8. Overall data indicate that

both student cohorts made marginal performance gains when compared to the assessment in 2009. However, a more detailed analysis of the data demonstrates that, despite overall longitudinal gains, a persistent gap continues to exist between Black and White students, and that the narrowing of this achievement gap has slowed in recent years. For example, fourth grade math data reveal a discrepancy of 27 percentage points in 2003, and 26 points in 2005, 2007, and 2009 consecutively, and 25 points in 2011 (See *Figure 1*). For eighth grade students, the achievement gap narrowed slightly from 35 points in 2003 to 34 points in 2005, and then 32 points in 2007 and 2009; the most recent data in 2011 indicate a 31 point discrepancy (See *Figure 2*) (NAEP, 2011). NAEP also periodically collects data for twelfth grade student math performance. Because the initial baseline collection of data began in 2005, the ability to make longitudinal comparisons is not readily available. However, Black versus White achievement discrepancies of 31 percentage points in 2005 and 30 points in 2009 were recorded (NAEP, 2009).

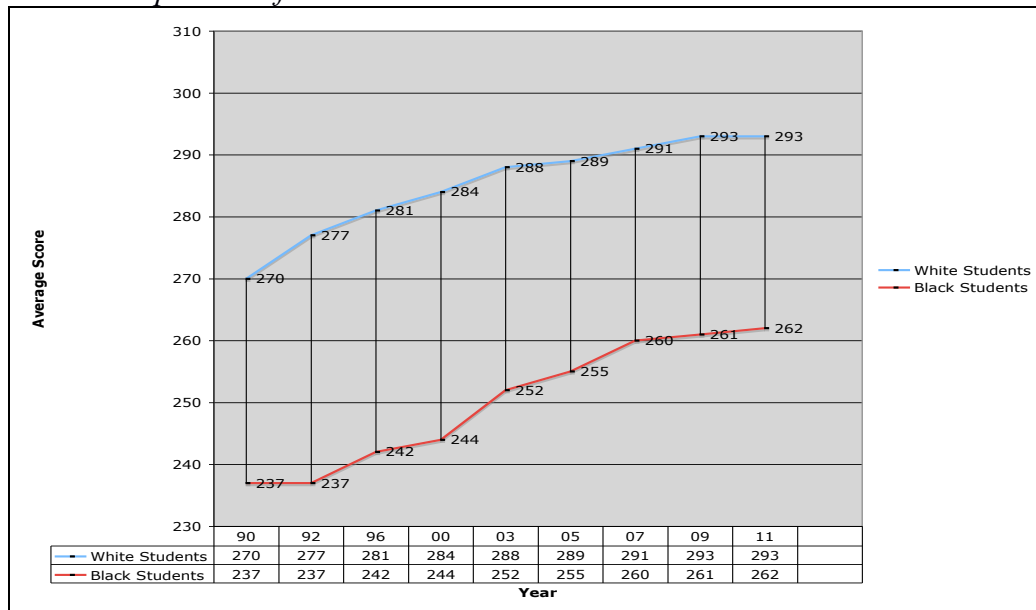
The 2007 Trends in International Mathematics and Science Study (TIMSS) summarized the overall mathematics achievement levels of fourth and eighth grade students in comparison to students in participating international countries. Data from the TIMSS study, while not disaggregated by demographic characteristics, were analyzed by mathematical content strands and cognitive domains. In mathematical content, students in grade 4 were measured in knowledge of Number, Geometry and Measurement, and Data Display. Students in grade 8 were measured in Number, Algebra, Geometry, and Data and Chance. All content areas were assessed at the different cognitive levels of Knowing (basic knowledge of math facts, concepts, etc.), Applying (applying knowledge/concepts to solve problems), and Reasoning (multi-step problems, manipulating complex mathematical contexts, etc.).

Figure 1  
*NAEP Comparison of 4<sup>th</sup> Grade Math Scores: Black Students vs. White Students*



\*Scale of scores ranges from 0-500  
 Source: National Assessment of Educational Progress 2011 Report

Figure 2  
*NAEP Comparison of 8<sup>th</sup> Grade Math Scores: Black Students vs. White Students*



\*Scale of scores ranges from 0-500  
 Source: National Assessment of Educational Progress 2011 Report

In the United States, both fourth and eighth grade students performed lower as the cognitive domains became more abstract and complex; students were strongest in the “Knowing” domain, and weakest in the “Reasoning” domain (TIMSS, 2007).

Though NAEP and TIMSS measure mathematics achievement through somewhat different constructs, the examination of these data establishes a framework for relevant research questions. Despite the trends and discrepancy phenomena highlighted by these studies, there is insufficient information provided with respect to the *nature* of the discrepancy within the knowledge strands assessed by NAEP (number properties and operations; measurement; geometry; data analysis, statistics, and probability; and algebra). NAEP does align knowledge strands with a description of proficiency levels (basic, proficient, advanced), but these data are not disaggregated by demographic subgroups within the nationally released report. Furthermore, there is very little research that gives detailed analysis concerning which content strands are the most problematic for students belonging to specific subgroups. TIMSS provides mathematics performance data by knowledge strand and cognitive domain for the United States as a whole, but without the ability to disaggregate the information by demographic variables. Therefore, data provided in these studies is limited to being more general than specific; consequently, most research focusing on mathematics achievement gaps addresses the disparities in broad terms.

From 2001-2012, in compliance with No Child Left Behind [NCLB], the state of Virginia assessed all students annually in reading and mathematics, among other subjects not mandated by the federal law. Student achievement in math was measured through tests that are aligned with the Virginia Standards of Learning (SOLs), the state's adopted curriculum framework. Additionally, student pass rates were reported by demographic subgroup at the school, district, and state level to determine which schools were fulfilling the law's Annual Measurable

Objective [AMO] requirements. Based on this data, schools and districts not meeting AMOs in as little as one of the multitude of categories were assigned “improvement,” status with accompanying sanctions that were graduated for each year in “improvement.” The goal of NCLB was to ensure that schools were accountable for the achievement of all students, regardless of ethnicity, disability status, or socioeconomic status, etc. with the ultimate aim of all schools achieving 100% pass rates in reading and math by 2014 (NCLB, 2001). However, toward the end of the most recent decade, it became evident that some states needed more flexibility in reporting and capturing how schools and school districts were making progress.

In 2012, Virginia (along with several other states) applied and was granted a waiver from the stringent pass rate requirements outlined by NCLB. The Virginia waiver plan focuses on establishing benchmarks for failure rate reduction, as opposed to the achievement of set pass rates; the goal of the new accountability plan is to reduce failure in reading and math by 50% within six years. Virginia’s NCLB waiver also addresses student achievement in Title I schools, divided into “Priority” or “Focus” categories based upon need, by establishing three “proficiency gap groups” comprised of students that have historically had difficulty meeting proficiency standards on the state’s assessment. Much like the groups that NCLB targeted initially, students in these groups are students with disabilities, socioeconomically disadvantaged students, English language learners, and Black and Hispanic students. Furthermore, schools in “Priority” status will receive services from a school turnaround agency sponsored by the state, and “Focus” schools will receive coaching at the district-level to implement instructional programs aimed at reducing the failure rate for at-risk students. Title I schools would not, however, be subject to the original sanctions outlined by NCLB, which include offering school choice or private tutoring. Non-Title I schools are still required to track student achievement by demographic

subgroup, and implement comprehensive improvement plans to raise the achievement of students not meeting the failure rate reduction benchmarks. Finally, Virginia's NCLB waiver aligns a portion of teacher and principal performance evaluations with student academic progress (VA DOE, 2012)

Regardless of the NCLB waiver, the state of Virginia possesses its own accreditation system and curriculum standards by which student achievement is assessed. This includes SOLs for mathematics in Grades K-8, and in each of the specialized math curriculums (i.e. Algebra, Geometry, Trigonometry, etc.) for high school level students. The skills identified by each math SOL are classified by content strands that increase in complexity as the standards progress. In kind, every math SOL assessment question is also categorized under the applicable content strand, and is intended to be a representation of a student's ability to answer questions and solve problems in a conceptual area, at varying degrees of difficulty. While mathematics skills are adjusted for grade-level and developmental appropriateness, the math SOL content strands remain constant from Kindergarten through eighth grade. These content strands are similar to those used by NAEP and TIMSS: Number and Number Sense; Computation and Estimation; Measurement; Geometry; Probability and Statistics; and Patterns, Functions, and Algebra (VA DOE, 2009). Additionally, the content strands in the Virginia Math SOLs mirror the essential math concepts outlined by the Common Core State Standards for Mathematics (VA DOE, 2011), an initiative by the National Governors Association for Best Practices and the Council of Chief State School Officers to ensure that all students are career or college ready (NGA & CCSSO, 2010).

Like NAEP and TIMSS, the state of Virginia also makes public the results of annual SOL assessments in mathematics through a "Report Card." By utilizing the Virginia Department of



Education's website, members of the public are able to generate a performance report for any school district or school in the Commonwealth; likewise, a report can be created that details the achievement of all students in the state over the past 3 years of assessments. Mathematics results from 2008-2010 reflect a persistent achievement gap by ethnicity and SES that has narrowed slowly, similar to the trends observed in NAEP data. The overall performance discrepancy of Black vs. White students was 15 percentage points in 2008, 13 points in 2009, and 12 percentage points in 2010. For socioeconomically disadvantaged students, the pass rate was 73% in 2008, 77% in 2009, and 80% in 2010; comparisons to socioeconomically advantaged peers are not available in the report (Virginia School Report Card, 2011). However, also similar to NAEP, no information concerning content strand performance by ethnicity or SES is provided for students in Virginia. The data analysis is strictly limited to pass rates, and the percentage of students who achieved "proficient" or "advanced" performance. Again, the specific nature of the achievement discrepancy is unclear, and questions remain concerning information that may lie within the disparity if it were analyzed by ethnicity and/or SES. Given the recent calls for increased opportunity to learn more complex math skills (NCTM, 2011), it is puzzling that most reported data and available research provide such a limited view on the *gaps within the gap* that occur specifically along ethnic and socioeconomic lines.

## **Overview of Study**

The current study attempts to discover specific details about the mathematics achievement gap on the Virginia SOL Assessments between Black and White students, socioeconomically disadvantaged and advantaged students, at the elementary and middle school levels. It also attempts to identify any relationship between these three variables. Specifically,

student achievement in every mathematics content strand by school level is examined to identify the varied discrepancies that contribute to the cumulative math achievement gap that exists within these populations. Pre-existing SOL mathematics performance data from three years (2009, 2010, and 2011) was obtained from a large school district in Virginia with a demographic and socioeconomic profile comparable to the state's overall demographic/socioeconomic profile for students in grades 3-8. After obtaining the data file, differences in the scaled scores for the five reporting categories measuring achievement in each respective mathematics content strand were analyzed for statistical and practical significance among the three independent variables for each year. Factorial analysis was also conducted to determine if there is an interaction present between the independent variables. The intent of this study is to obtain a detailed understanding of the math achievement gap for two at-risk populations in Virginia, and note any overall and specific significant differences between the performance of the groups at elementary and middle school levels.

## **Overview of Literature**

Education in America has historically been available to its citizens on an inconsistent equitable basis (Tyack, 1974; 2003; Zimmerman, 2002). Public education systems began forming during a time when lines segregating different races and socioeconomic classes of people were very defined, and viewpoints concerning people of various ethnicities existed mostly within the context of superiority vs. inferiority. As time progressed and public education became a priority, however, the effects of racism and poverty persisted even as education in America became compulsory and a right guaranteed under the law. School systems struggled with integration, equitable distribution of resources, and numerous persistent social issues

reflecting many decades of culturally normed discrimination, exclusion, and devaluation of education (Tyack; Zimmerman). The consequences of America's educational “back story” became evident when student achievement data began to be collected by NAEP, revealing significant achievement disparities between Black and White students in reading and math.

While education disparity can be directly related to the historical neglect of “lower status” populations (Graham, 2005), other factors exist in present day context that complicate efforts to realize the advancement needed to close achievement discrepancies by ensuring that children are adequately primed to learn when they begin formal schooling. These influences include parenting styles and skills within the home environment (Mistry, Benner, Biesanz, Clark, & Howes, 2010; Walker & MacPhee, 2011), exposure to opportunities to develop language and vocabulary (Brooks-Gunn & Markman, 2005), and reading and literacy behaviors within the home environment (International Reading Association, 2011; Zimmerman, Rodriguez, Rewey, & Heidemann, 2008). Variability in these aspects of children's early life is deeply rooted in historical disadvantage, scarcity of family economic resources, and differences in cultural norms within diverse communities.

Understanding the achievement gap solely as it relates to mathematics has been a somewhat elusive endeavor for researchers, most likely because formative knowledge in math is less emphasized in very early childhood than observable language learning and functional language usage (Eddy & Easton-Brooks, 2011). Therefore, researchers have used a variety of approaches to attempt to understand the roots of mathematics achievement disparities. These include research on the relationship between cognitive development and early math skills (Cooper & Schlessner, 2006), differences in teachers and teaching styles (Desmione & Long, 2010; Georges & Pallas, 2011), and curriculum implementation (Klein, Starkey, Clements,

Sarama, & Iyer, 2008; Mac Iver & Mac Iver, 2009). Results have been inconsistent, and have posed more questions than answers for researchers.

While math achievement has improved nationally, and ethnicity-based gaps have narrowed in recent decades, there is suggestion in the literature that these gains could be attributed to knowledge increases and mastery of basic skills only (Ladson-Billings, 1997). Similarly, socioeconomically disadvantaged students have increased their mathematics achievement at disproportionately basic levels. One trend already outlined in the research is the tendency for teachers to use conceptually simple methods to instruct at lower cognitive levels with students from historically underserved populations, primarily ethnic minorities and poor students (Ladson-Billings). This may help to explain the gains seen in less complex mathematical content by these populations (Lubienski & Crockett, 2007). However, the lack of study on the *specific* skills that compose the Black/White and socioeconomic disadvantaged/advantaged mathematics achievement gap points to the need for detailed gap analysis research. Understanding the particulars about what conceptual knowledge is disproportionately problematic to at-risk and underserved populations can inform educators' efforts to ameliorate the achievement gap issue (Lubienski, 2008). Gap analyses cannot only show what skills are discrepant, but for whom they are discrepant and when they tend to become disproportionately discrepant (Reardon & Robinson, 2007). There is also precedent in the literature for other potential information to be gleaned from mathematics gap analyses, including the effects of school reform models on specific math skills (Mac Iver & Mac Iver, 2009). Currently, there is no available research specific to Virginia that analyzes mathematics achievement discrepancies in the state curriculum by content strand. Given the potential benefit to understanding mathematical areas in which our historically underserved students need the

most support, it stands to reason that a gap analysis of Virginia SOL math data would be beneficial in the overall mission to educate and prepare students for inclusive participation in the 21<sup>st</sup> century.

### **Rationale and Purpose of Study**

While researchers and practitioners have performed general investigations about the mathematics achievement gap, there is a wealth of information that can be obtained by conducting research on the specific details of mathematics achievement discrepancies. Such information may reveal a variety of disparity-related aspects of math education, including at what age/grade level the gap begins, the conditions under which it increases or decreases, and the tendencies of the gap to affect students' progress as they continue their education. The knowledge produced by the current study could be used in a variety of ways. Detailed analysis of Virginia mathematics SOL data could be used primarily to explore strengths and weaknesses in the instructional programming framework used by the State of Virginia. In turn, school districts may utilize the results to influence how instructional and human resources are distributed in an equitable way. The current study could add to the emphasis of the need for professional development influencing classroom practices, teaching methodologies, and strategies that stimulate higher order thinking skills in the area of math. Information from this study may also inspire related future research inquiries which could be conducted, using the same research design, to answer questions that pertain to a specific intervention or program at the district or school level. For example, if a school district has been implementing a specialized math program for its elementary students, then a comparable data analysis can inform administrators on the program's effectiveness in different areas of conceptual mathematics

knowledge.

The purpose of the current study focuses not only on continued understanding and evaluation of the effectiveness of the mathematics curriculum in Virginia, but also the effect of current instructional practices, and the establishment and/or continuance of equitable practices. It has implications for professional development of teachers and school administrators as they seek to evaluate the programs they are currently using, and implement new programs and methodologies for students.

### **Research Questions**

1. When controlling for student gender and disability status, is there a statistically and/or practically significant difference in overall mathematics achievement between Black and White students at elementary and middle school levels on the Virginia Math SOL Assessment?
2. When controlling for student gender and disability status, is there a statistically and/or practically significant difference in overall mathematics achievement between socioeconomically disadvantaged and advantaged students at elementary and middle school levels on the Virginia Math SOL Assessment?
3. When controlling for student gender and disability status, is there a statistically and/or practically significant difference in strand-based mathematics achievement between Black and White students at elementary and middle school levels on the Virginia Math SOL Assessment?

4. When controlling for student gender and disability status, is there a statistically and/or practically significant difference in strand-based mathematics achievement between socioeconomically disadvantaged and advantaged students at elementary and middle school levels on the Virginia Math SOL Assessment?
5. When controlling for student gender and disability status, is there an interaction between race, socioeconomic status, and school levels as independent variables in overall and strand-based mathematics achievement on the Virginia Math SOL Assessment?

## **Design and Methods**

The current study is a quantitative descriptive analysis of Virginia SOL mathematics data over three school years (2009, 2010, and 2011) by reporting category for elementary and middle school students in a large, diverse school district in Virginia. Total mathematics achievement scores by school level are examined to identify statistical significance of any discrepancy by race and SES. Analysis of Covariance (ANCOVA) is used to identify these significant differences, while controlling for gender and student special education status as covariates. Scaled scores for each content strand are then examined and compared between Black and White students, and socioeconomically disadvantaged and advantaged students, to identify the main effects of the variables on content strand-based performance. Again controlling for student gender and special education status, Multivariate Analysis of Covariance (MANCOVA) is utilized to determine any statistically significant differences between the levels of each independent variable for strand-based mathematics achievement. As part of the ANCOVA and MANCOVA, 2x2x2 factorial

analysis is utilized to determine the potential presence of any statistically significant interaction among the independent variables. In addition to statistical significance, practical significance is examined by calculating the effect size ( $\eta^2$ ) of any statistically significant difference encountered.

### **Definition of Terms**

Achievement- Student performance on the Virginia SOL Assessment, relative to the established pass/fail benchmarks on the total scaled score (overall mathematics achievement) and scaled scores in each reporting category (strand-based mathematics achievement)

Content Strand- Classification by conceptual topic assigned to mathematics content in Virginia. In the Virginia SOL Curriculum, there are five (5) mathematics content strands: Number and Number Sense; Computation and Estimation; Measurement and Geometry; Probability and Statistics; and Patterns, Functions, and Algebra.

Reporting Category [RC]- Respective categories under which student achievement by mathematics content strand is reported. In the Virginia SOL Mathematics Assessment, there are five (5) reporting categories: RC1= Number and Number Sense; RC2= Computation and Estimation; RC3= Measurement and Geometry; RC4= Probability and Statistics; and RC5= Patterns, Functions, and Algebra.

Socioeconomically Disadvantaged- Descriptor used for a student who is eligible for and receives free or reduced lunch, per criteria established by the Virginia Department of Education



indicating economic deprivation.

Elementary School Students- Group of students who completed an SOL mathematics assessment in Grades 3, 4, and 5.

Middle School Students- Group of students who completed an SOL mathematics assessments in Grades 6, 7, and 8.

Standards of Learning [SOL]: Standardized curriculum by subject, topic, and learning outcome, adopted by the Virginia Board of Education, administered by the Virginia Department of Education, and instructed and uniformly assessed in every school district in Virginia.

SOL Assessment- Standardized test administered each year to all students in Virginia, based upon demonstration of knowledge of the Virginia SOLs, which provides the indicator of student achievement as defined in this study.

## **Chapter 2**

### **Review of Literature**

#### **Literature Review Methodology**

In the course of accessing research for this literature review, several strategies were used to enhance the quality of the sourcing and to provide rigor to the research process. For the historical background section, the primary source for the research was the shelved library collections at Virginia Commonwealth University pertaining to the history of American education. Several works on the relevant themes of the topic were selected, including the general educational history, the implications of the *Brown vs. Board* decision and its effects, and the struggle of the country to adapt to legal and social changes. The most recent works available were selected to provide a contemporary perspective on educational history. For the sections that involved empirical research studies, “ERIC via FirstSearch” was the primary database used to access the articles. Various key words relevant to the topics discussed were entered; these included “mathematics,” “achievement,” “achievement gap,” “disadvantaged,” etc. When less specific information was needed for a broader scope of analysis, the terms were generalized (i.e. “achievement gap” and “Black”). To add an additional filter to the search results, the “Peer Reviewed Only” option was always selected when the search terms were used. Articles were sorted by date so recent research was reviewed and selected first. Based on the most narrow search results with these filtering options, approximately 235 articles were located on the most specific topic. Of that number, approximately 32 articles (13%) from peer reviewed scholarly journals met the criteria for inclusion in the literature review. Finally, the “Cited Reference Search” tool in Web of Science was used for various articles to backtrack and refer to the

frequency in which they have been cited in other peer reviewed studies. This resulted, at times, in the exclusion of articles from the literature review due to the discovery that the research was less relevant to the current topic than initially believed.

### **Historical Background of Disparities in Education**

Educational opportunity in America varied widely throughout different periods of the country's history, and was available inconsistently to people of contrasting backgrounds, ethnicities, social classes, and even geographic regions and localities. The earliest efforts to educate children in public school began in the New England region of colonial America in the mid 1600s (Reef, 2009). Students were primarily instructed in the basic reading of English, as well as some fundamental instruction of Latin literature, to equip them with the necessary skills to read the Bible and participate as morally upstanding members of their small society. Early public schools were different than secondary schools, which concentrated on more complex academics and classical education. Similar to the educational systems in European nations, divisions along social class lines in public schooling were prominent even in the early days of America. Primary schools were designated for the sons of farmers and laborers, and Latin grammar schools were intended for boys from more affluent families of lawyers, merchants, or clergymen. These seeds of separate educational opportunity according to class and race were the foundational root system by which our public schools began segmenting and apportioning the quality of learning for children from varied backgrounds (Reef).

During the 18<sup>th</sup> century, differences in educational quality and opportunity tended to be strongly related to the economic and class-oriented atmospheres of certain regions (Reef, 2009). The northern and New England colonies slowly improved public schooling based upon increased

economic success and a philosophy that generally valued public financial contribution to schools. However, public education was not highly valued in the south, even after the American Revolution and well into the 19<sup>th</sup> century. Southern economies were primarily agrarian, and most learning revolved around continuing the agricultural traditions of the region. Basic instruction was sometimes provided for, but usually with significantly under-educated teachers and substandard facilities (Reef). Tyack (1974) pointed out that education in the South was also very community oriented; vocations were learned on the farm or from other localized service providers, moral instruction took place in the church, and recreation was something that occurred simply by virtue of children playing outside. Thus, a more formal approach to education was seen as unnecessary and neglected, which led to what scholars at the time referred to as the “Rural School Problem.” While public educational quality and opportunity differed based on the economic infrastructures and community values, the stark difference between the educational experience of Black and White children is a constant and unvaried theme in the the history of American education (Tyack).

Graham (2005) noted the intersection of poverty, race, and educational opportunity in rural, mostly Southern communities through the 19<sup>th</sup> and early 20<sup>th</sup> century. Because formal education was not particularly valued in these communities, public funding of schools was meager, even for the children of White citizens. Black community members, however, were still not viewed as citizens that should be legally afforded access to an education, or most community resources for that matter. This southern “tradition” was ingrained through a combination of historical precedence, cultural norms, and legal decisions such as the Jim Crow Laws, and *Plessy v. Ferguson*, which established racial segregation broadly across all community venues in “separate but equal” facilities and access (Pulliam, 1991). This allowed local communities to

continue culturally sanctioned discriminatory practices in all aspects of daily life. However, Spring (1986) pointed out that the Supreme Court failed to define and clarify what constitutes “equal” facilities, and what reasonable access to resources entails. The reality is that the opportunity for Black children and families to access a public education, even in an atmosphere where the *best* circumstances for public schooling existed as underfunded and undervalued, was far from equal to that of White citizens (Graham).

Being poor or Black (and in most instances, being Black *meant* being poor) were two factors that dramatically affected peoples' ability to become educated by a hodgepodge of schooling systems that were unstable, even for those belonging to a more privileged social class (Tyack, 1974). The effects stemming from the lack of Black children's exposure to education were contorted into efforts that either suggested or “proved” their inferiority in the decades leading up to the *Brown* decision (Tyack). One such theme included the creation and use of Intelligence Quotient (IQ) testing to not only rank students and place them into programs, but also to infer that entire races of people existed along an inferiority/superiority continuum; the “Negro race” was determined to be the most intellectually inferior (Tyack, 2003; Spring, 1986; Good & Teller, 1973). Zimmerman (2002) and Pulliam (1991) noted that most textbooks used in schools prior to 1960 had made Black people and other minorities invisible, thereby neglecting their contributions and even their very participation in society; some suggested they were actually better off under laws imposing segregation. Graham (2005) referred to the “culture of low expectations” that existed during this time period for Black and poor people, which continuously undercut arguments made in favor of equal educational standards and access. More specifically, Noddings (2007) cited the “soft bigotry of low expectations” to refer specifically to educators who expected less from minority students. However, when racial integration became a

reality for public schools in the mid-late 20<sup>th</sup> century, certain consequences of years of repression were realized as barriers to Black children's meaningful participation in public education began to be lifted.

Racial segregation in public schools continued to be legally sanctioned until the 1954 Supreme Court decision *Brown v. Board of Education*, which declared that separate schools were inherently unequal. However, despite court ordered desegregation of all public schools in the United States, many communities and even entire states continued to fight for years against what they perceived as an attack on their culture. George Wallace, Governor of Alabama, infamously declared, “Segregation now, segregation tomorrow, segregation forever!” in his 1963 inaugural speech, a full nine years after the *Brown* decision (Reef, 2009). Pratt (1992) contextualized this resistance to desegregation in his analysis of school integration in the Richmond, Virginia area from 1954-1989. He describes the “massive resistance” of the Virginia government and local school boards through “policies of containment,” which included pupil placement boards which enacted policies that encouraged *de facto* segregation, or segregation that exists without the application of a law. Also employed were strategies such as offering “freedom of choice” in selecting schools, which played upon the already racially segregated housing patterns that existed in the area. Continuing through the late 1960s and early 1970s, these policies were part of a campaign of “passive resistance” to integration of the schools. This brand of institutional racism was common in Richmond, and widely across the south, for several years after the *Brown* decision; many localities attempted to maintain similar policies years after the abolition of *de jure* segregation (Reef; Tyack, 2003). Among the major challenges of desegregation for Black students was their sudden introduction into a system that for many decades had worked very efficiently constructing paradigms to justify their exclusion, and prevent them from accessing

educational opportunities.

In addition to the resistance of racial integration via policy maneuvers, formerly segregated schools remained hostile toward the changes that prohibited discrimination on the basis of race. Pratt (1992) described the atmosphere in Richmond, Virginia area schools during the desegregation period as antagonistic toward children of color attending schools; subtle harassment by White students and use of prejudicial language was commonly cited as a factor that made students feel uncomfortable and unwelcome. Additionally, in order to attend school, many Black students had to leave their neighborhood environment and surroundings that were familiar to them, giving up their social emotional support structure. These factors existed consistently in the south and areas in which segregation had been part of the normed culture (Reef, 2009). Additionally, hostility toward Black children was not always overtly displayed, with institutional racism continuing to exist as part of primarily White cultures. Zimmerman (2002) recounted an experience by Martin Luther King, Jr. in which the children of an integrated school performed a play on “music that made America great.” While various songs from different immigrant groups were performed, there was no mention of Africa's extensive musical tradition. The program closed with all the children, White and Black, singing “Dixie,” an anthem that celebrates the southern “heritage” of slavery. While these sociocultural issues continued to exist in newly desegregated schools, the low levels academic achievement by Black students resulting from denial of educational opportunity was a problem whose significance was becoming increasingly evident.

During the mid and late 1960s, there were major policy developments in the field of public education that were associated with President Lyndon Johnson's “Great Society” movement. One example is the Elementary and Secondary Education Act of 1965, which ties

federal education funds for states to compliance with civil rights laws. However, around this time period, the quality of American public education was coming under scrutiny in general (Graham, 2005). Publications such as *The Schools* by Martin Mayer (1961), *Crisis in Black and White* (1964) and *Crisis in the Classroom: The Remaking of American Education* (1970) by Charles Silberman, and *Death at an Early Age* by Jonathan Kozol (1967) joined other works of protest literature about the state of America's public schools. These publications raised issues concerning not only the general quality of our educational systems, but the access to learning opportunities for students of different ethnicities and the education of poor children (Graham). While some of the books could be considered political in nature, the basis for their objection to low academic achievement of American students was not entirely off base.

#### *Measurement of Achievement and Reform*

In 1971, NAEP began reporting national achievement data on student reading performance, followed by mathematics performance in 1973. Results confirmed claims that America's students were achieving at mediocre levels. The national average performance for the NAEP Reading Assessment in 1971 was 208 for 9 year-olds, and 255 for 13 year-olds. NAEP Mathematics Assessment results in 1973 revealed that 9 year-olds on average achieved a score of 219, and 13 year-olds achieved an average score of 266. However, when the results were disaggregated by Black and White student performance, striking achievement disparities were immediately apparent. For 9 year-olds in 1971, Black students achieved an average Reading score of 170, while White students earned an average score of 214 (See *Figure 3*). Reading data for 13 year-olds revealed an average score of 222 for Black students, and 261 for White students (See *Figure 4*). Mathematics data on 9 year-olds in 1973 revealed that Black students on



average earned a score of 190, and White students achieved an average score of 225 (See *Figure 5*). For 13 year-olds, Black students earned an average score of 228, and White students on average achieved a score of 274 (See *Figure 6*) (NAEP, 2008). These substandard achievement scores did not go unnoticed, especially as the nation was slowly moving from the era of segregated schools to fully integrated systems, and spending federal money in the process.

Figure 3

*NAEP 4<sup>th</sup> Grade Reading Data Comparison, 1971-2008: Black Students vs. White Students*

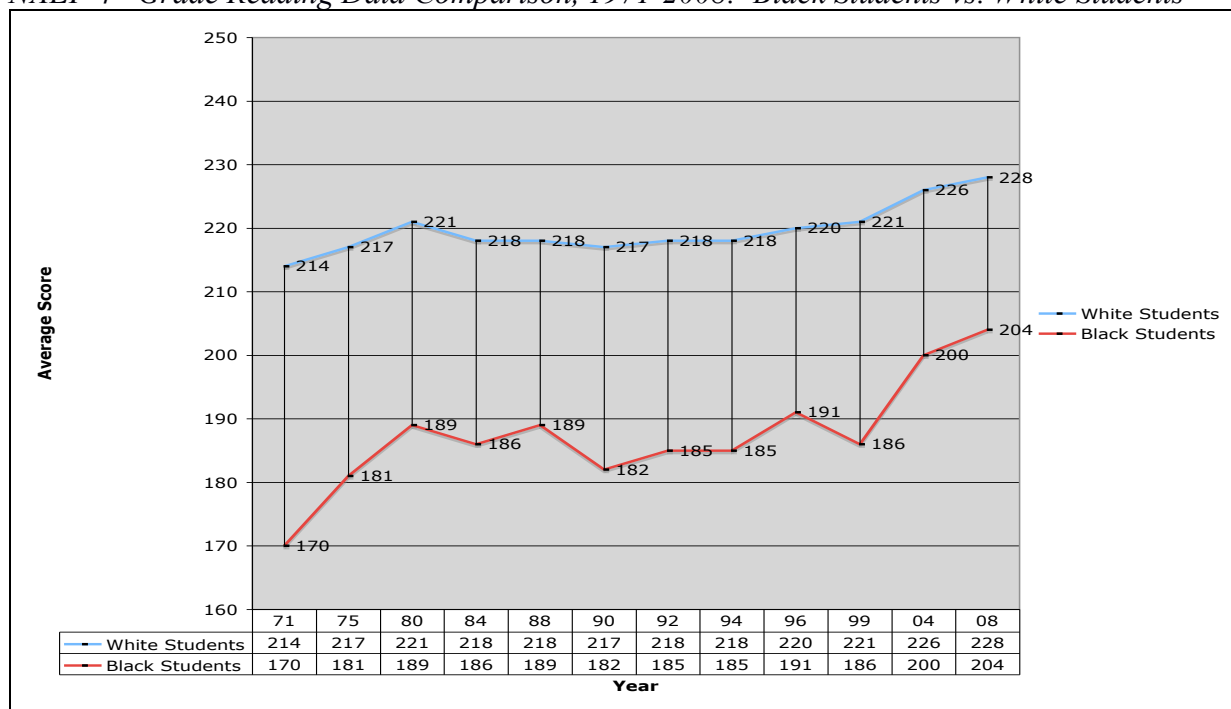


Figure 4

NAEP 8<sup>th</sup> Grade Reading Data Comparison, 1971-2008: Black Students vs. White Students

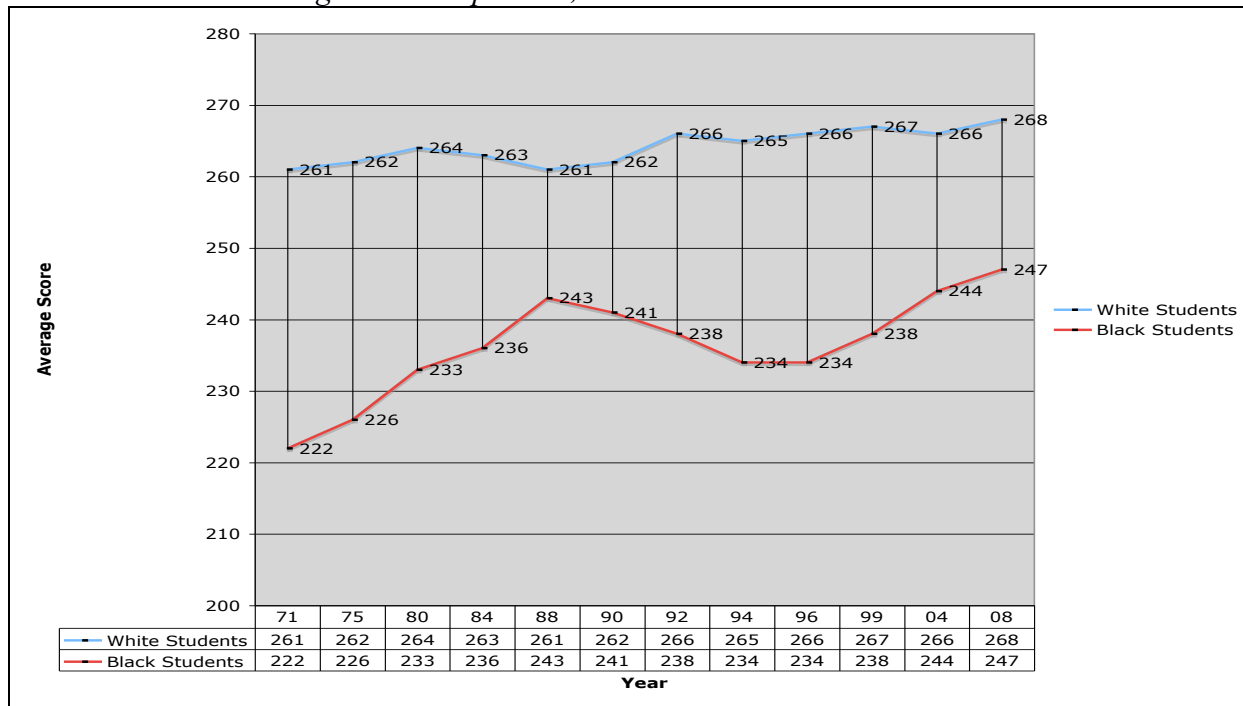


Figure 5

NAEP 4<sup>th</sup> Grade Math Data Comparison, 1973-2008: Black Students vs. White Students

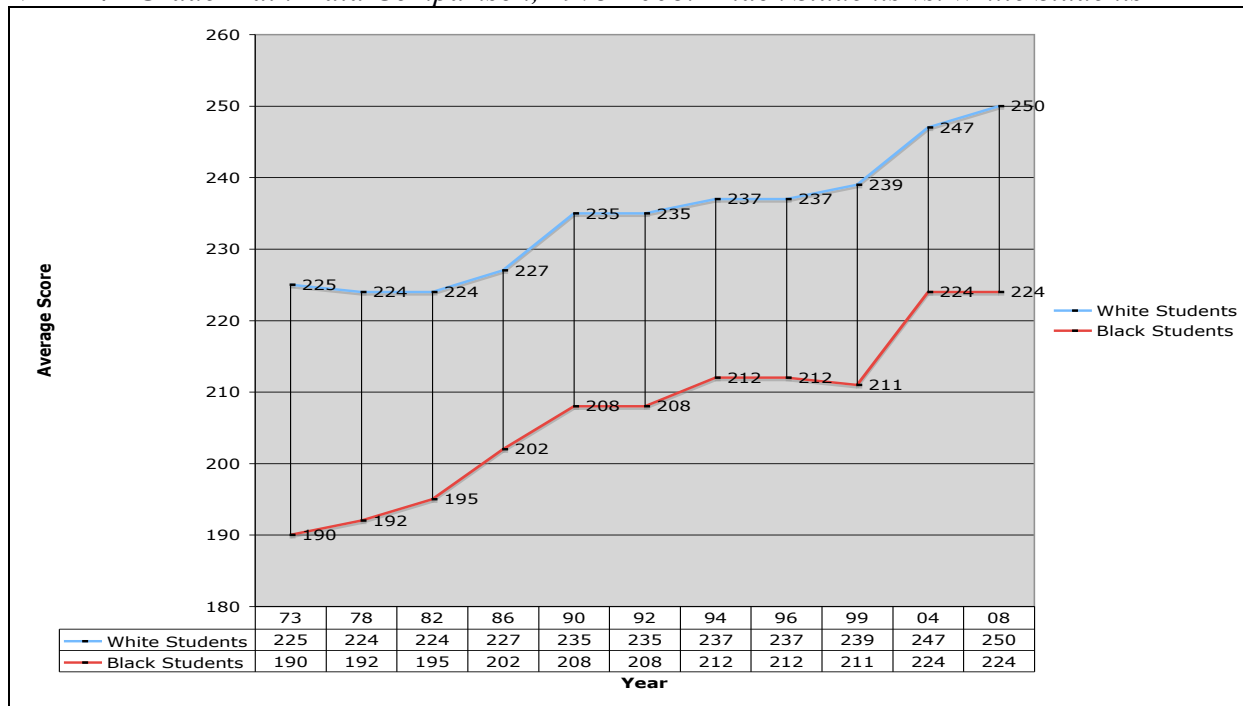
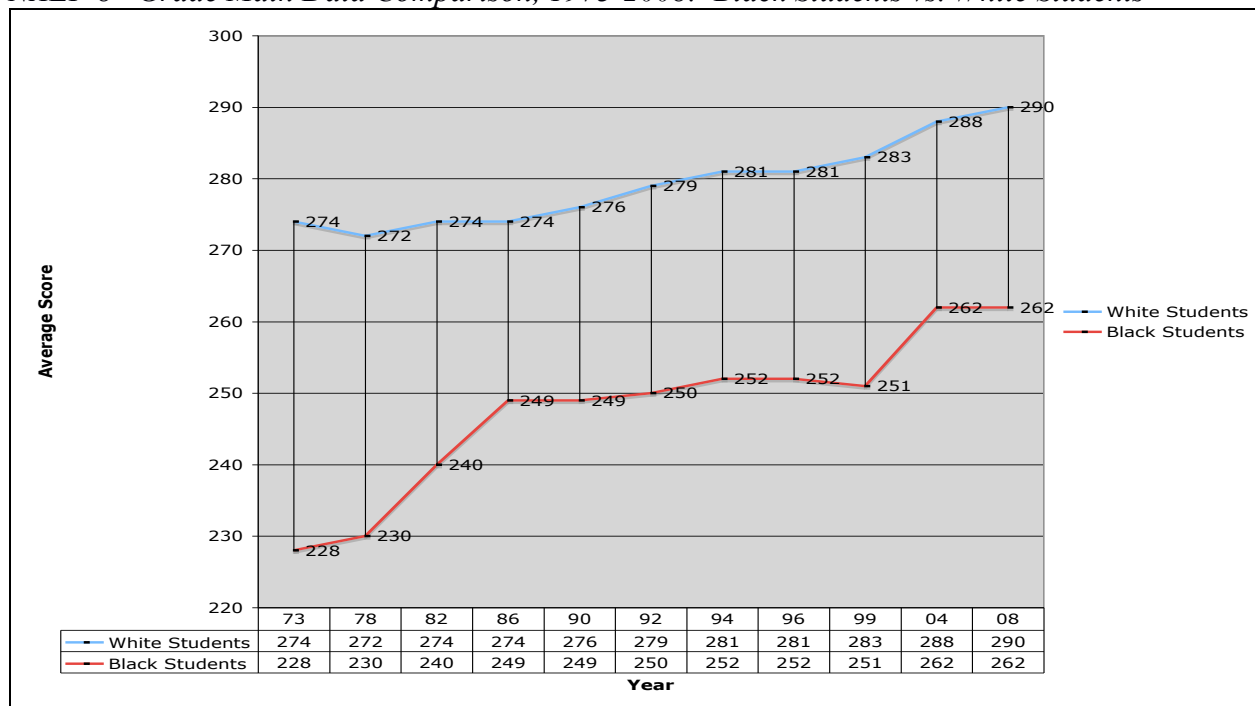


Figure 6

NAEP 8<sup>th</sup> Grade Math Data Comparison, 1973-2008: Black Students vs. White Students



\*Scale of scores ranges from 0-500 (all figures)

Source (Figures 3-6): NAEP 2008 Trends in Academic Progress Report

The National Commission on Excellence in Education was created by United States Secretary of Education T. H. Bell in 1981 to provide a summative assessment of the condition of education in America. Headed by David Gardner, the Commission released its report in 1983 entitled *A Nation at Risk: The Imperative of Educational Reform*. This document offered a critical view of our public education system and the achievement outcomes that the nation's schools were producing. Of the primary indicators of concern, the report cites the functional illiteracy of 23 million Americans in the “simplest tests of everyday reading, writing, and comprehension,” posits a functional illiteracy rate for minority youth potentially as high as 40%, and impugns the mathematics knowledge of older students, primarily secondary students and post-secondary adults. While many interpreted *A Nation at Risk* to be politically motivated, it

certainly called attention to the need to improve educational outcomes for students. The issue of the achievement gap along racial lines, however, was not specifically addressed in the report. NAEP data shows that disparities between Black and White students continued to exist, even after many of the periodic educational reforms of the 1980s and 1990s were enacted.

Historical NAEP data do reveal that Black students have, as a cohort, made significant gains in reading and mathematics achievement levels since 1971 and 1973 respectively. Reading scores for Black 9 year-olds increased a total of 34 points from 1971 to 2008, and 25 points for Black 13 year-olds during the same time period. With the exception of three years (1984, 1990, and 1999), 9 year-olds improved by a minimum of 3 points in 1988 and 1992, and a maximum of 14 points in 2004. Scores in reading for 13 year-olds were less stable, with a 6 year negative trend that reflected a 9 point decrease between 1990 and 1996. In spite of this, all other assessment data indicates reading gains from 3 points in 1984 to 7 points in 1975 and 1988. Mathematics scores reveal even more significant improvement for Black students, with both 9 year-old and 13 year-old groups scoring 34 points higher between 1973 and 2008. Gains were consistently positive for Black 9 year-olds, with the exception of 1999 where scores decreased by one point. Score increases ranged from 2 points in 1978 to 13 points in 2004. For Black 13 year-olds, gains were also consistently positive. The 13 year-old cohort saw the same one point decrease in 1999 as the 9 year-old cohort; however, similarly, this is the only year with a recorded loss. Math achievement gains for 13 year-olds ranged from one point in 1992 to 11 points in 2004 (NAEP, 2008). These trend data represent relatively positive news in the area of educational achievement for Black students. However, one of the most striking aspects of the NAEP data is also the achievement disparity between Black and White students, which is a feature that runs through all NAEP assessments since they began.

It is a fact that achievement disparities between Black and White students revealed in NAEP have narrowed significantly since data began being collected. The achievement gap in reading closed from 44 points in 1971 to 24 points in 2008 for 9 year-olds, and from 39 points to 21 points for 13 year-olds during the same time period. In mathematics, the achievement gap for 9 year-olds narrowed from 35 points in 1973 to 26 points in 2008, and from 46 points to 28 points for 13 year-olds. In each case, the gap closure from the early 1970s to 2008 represents a statistically significant difference at the  $p < .05$  level. Interestingly, there is one aspect of the disparity improvement that distinguishes reading from mathematics gains. In reading, achievement gap closures have been repeatedly found to be statistically significant at the  $p < .05$  level for both 9 and 13 year-olds. Out of the 12 reading assessments given to since 1971, 8 achievement gap closures have been assessed as statistically significant for both 9 year-olds and 13 year-olds when compared to the 2008 data. In contrast, mathematics achievement gap closures were far less likely to be statistically significant. Since 1973, there have been 11 NAEP mathematics assessments; only 2 gap closures for 9 year-olds and 3 for 13 year-olds have been statistically significant when compared to the 2008 data (NAEP, 2008). This means that decreases in mathematics achievement gap by race have been much less “powerful” than those in reading, and that the narrowing of mathematics disparities by race is not any more remarkable than average increases that both White and Black students made in the same year.

### **The Achievement Gap, Race, and Socioeconomic Status**

Scholars have offered different perspectives concerning the reasons for the pervasive achievement gap between Black and White students. Caldas and Bankston (2005) described America's treatment of Blacks through the history of the country. In addition to the evils of

slavery itself, which denied people the right to their own humanity, laws were passed in certain states that expressly forbid teaching and educating slaves. After the 14<sup>th</sup> Amendment to the Constitution was passed outlawing slavery, the Freedman's Bureau was created and assisted in establishing schools with the intent of spreading literacy to recently freed slaves. Strides were made during this time period to increase the educational opportunity of Black children, but the realities of unequal school facilities, poor instructional resources, and low quality teachers seriously inhibited this effort. Until landmark legal decisions of the 1950s and 1960s guaranteeing access to education regardless of race, “much of the Black-White achievement gap could be attributed directly to oppression, discrimination, and segregation” (Caldas & Bankston).

Paige and Witty (2010) also affirmed the role that the country's history of abuse toward Blacks has played in the creation and persistence of the Black/White achievement gap. In addition, they also posit some contemporary explanations for the disparity in an effort to demonstrate the multi-dimensional quality of this issue. One example is the socioeconomic disparity that exists concurrently with race as a demographic variable and the achievement gap between Black and White students. As Graham (2005) pointed out, poverty has a negative correlation with educational opportunity through the history of our public schools systems, even when ethnicity is not a factor. This explains why educational attainment in poorer communities has, as a general rule, tended to lag behind that of students in more affluent localities. However, other variables related to SES and race have been identified as problematic for cognitive development and academic readiness skills, thereby contributing to the achievement gap between Black and White students. Certain factors, such as parental influence, language/vocabulary development, and literacy behaviors in the home, appear in the literature as contributory to achievement gaps in general. Several studies highlight the association between these elements

and decreased educational attainment.

### *Parental Influence*

Parenting behaviors more common in minority and socioeconomically disadvantaged households have been cited as a variable correlated school readiness among young children. Before examining this topic, it is important to underscore the point that a minority individual is not inherently considered low SES, and one who is low-SES is not minority by default. There is a propensity for these two demographic variables to be conflated in the literature due to their strong associations with each other (Pugello, Iruka, Dotterer, Mills-Koonce, & Reznick, 2009; Bluestone & Tamis-Lamonda, 1999). Jeanne Brooks-Gunn, a Virginia and Leonard Marx Distinguished Professor of Child Development and Education at Columbia University, conceptualizes parenting skills into seven categories: Nurturance, Discipline, Teaching, Language, Monitoring, Management, and Materials. In her experience on the subject of child development with respect to parenting skills, she details how research indicates that Black mothers are more likely to have less developed skill sets than White mothers in the areas of nurturance, discipline, teaching, language, and materials. Dr. Brooks-Gunn cites the tendency in research for Black mothers, along with low-SES mothers, to be more authoritarian than White mothers, and the increased likelihood of utilizing coercive punishment techniques such as spanking. It should also be noted, however, that much research measures the relationship between parenting practices and non-racial primary variables (i.e. single parent households), with race being a *secondary* variable that is accounted for. For example, more Black mothers are single parents than White mothers, so the relationship between single parenthood and school readiness also appears as a relationship between race and school readiness. However, when race

itself is isolated as an independent variable, the literature is not always consistent. Brooks-Gunn and Markman (2005) pointed to research that suggests children of Black mothers who use a combination of authoritarian and “tough love” skills (coupling harsh control with warmth/firmness) have higher IQs than Black children exposed only to classic authoritarian parenting styles. Nevertheless, the researchers state that variances in parenting behaviors that have the appearance of existing along racial/ethnic lines do play a role in the racial/ethnic differences in school readiness. When parenting skills by racial category is controlled for, gaps in the school readiness of Black vs. White children narrow between 25% and 50% (Brooks-Gunn & Markman). For the purposes of this literature review, race *and* SES will be examined in the literature concurrently and independently.

Joe and Davis (2009) researched the effects of parental behaviors/influence on school readiness and early academic achievement in Black boys. Using pre-existing public use data from the Early Childhood Longitudinal Study- Kindergarten Class (ECLS-K), the investigators identified 1,616 Black males in kindergarten and their parents for inclusion in the study. The median age of the sample was 5.44 years old, with 78.3% of the students attending full-day kindergarten programs (21.7% considered less than full day), and 88.9% of the total sample attending public schools. Data on the children's reading skills (letter recognition, print familiarity, sound identification), mathematics skills (measuring, problem solving, conceptual/procedural knowledge), and general knowledge (knowledge of natural sciences and social studies) were compared with parental responses that measured the frequency at which parents read to their children, discussed ethnic heritage, discussed nature or engaged in science projects, and attended parent/teacher conferences. Additionally, other demographic data such as SES and parental education level were included as independent variables. The study found



statistical significance between parents reading to children and students' reading skills ( $p < .05$ ), discussing ethnic heritage and children's math skills ( $p < .05$ ), and reading and general knowledge ( $p < .01$ ). Discussing nature and engaging in science projects was very significantly related to the children's general knowledge ( $p < .001$ ). Perhaps the most striking finding of the study was the continued significant link between SES and school readiness. Skill weaknesses in the areas of reading, mathematics, and general knowledge and low SES were all significantly related at the  $p < .001$  level. While the study did identify relationships between school readiness and reading, communication/discussion, and parental involvement, there was also a strong secondary finding in the relationship between decreased school readiness and low SES.

Another recent study (Mistry, Benner, Biesanz, Clark, & Howes, 2010) examined the relationship between responsive parenting practices and family language/literacy behaviors to children's school readiness in a diverse sample of low-SES young children ( $n = 1,851$ ; White = 38.6%, Black = 32.9%, Hispanic/Latino = 23.3%, Other = 5.2%). Data from the National Early Head Start Research and Evaluation Project was obtained and analyzed to identify the correlates and effect sizes of maternal warmth and language stimulation, described as family and social risk individually and cumulatively, on pre-kindergarten students' problem behavior (aggression, hyperactivity, withdraw), regulation (sustained attention, engagement with parent, quality of play), and achievement (letter/word identification, applied problems, receptive vocabulary, pre-literacy book knowledge/reading comprehension). Structural equation modeling (SEM) was used to test for both the magnitude and significance of relationships among predictor, mediator, and outcome variables. Additionally, the use of SEM allowed the investigators to simultaneously test for direct and indirect effects of the independent variables on the dependent measures. Among other findings, the research identified a significant relationship between

parental warmth/responsiveness and pre-K achievement and reduced problem behavior ( $p < .001$ ), and higher levels of regulation ( $p < .05$ ). The study also found that language stimulation was significantly related to higher levels of pre-K achievement ( $p < .001$ ), regulation ( $p < .01$ ), and reduced problem behavior ( $p < .05$ ). The importance of language development and stimulation is discussed in the next subsection of this literature review.

Walker and MacPhee (2011) studied the effects of parental control strategies on children's school readiness in 199 low-SES families of diverse backgrounds. Interestingly, the vast majority of the sample (96%) was comprised of Hispanic, White, and Native American families with little representation of Black families. The remaining 4% of families were classified as "other," and it is unknown whether any Black families were included in this category. The researchers measured cognitive development, social competence, and motivation to problem solve/complete tasks of children ranging in age from 3.00-5.56 years old ( $M = 4.11$ ). The results were compared with parental responses concerning their child-rearing practices, including parent anger, parent control style, and items intended to quantify their sentiments regarding problematic child behavior. The study found a statistically significant association between parental support/control strategies and school readiness in the cognitive domain. Additionally, parents' use of coercive behavioral control strategies (i.e. spanking, harsh criticism) were inversely and significantly related to school readiness in the cognitive and social domains of the children. The researchers also noted that social skills and motivation to complete tasks mediated the relationship between coercive parenting strategies and children's cognitive developmental level. This is an important point because it highlights the non-parental influences, such as a supportive social/emotional preschool environment, approaches to learning, etc., that challenge arguments which claim a disproportionate influence of parenting styles on

children's development. The investigators make an additional contribution to the literature in establishing a “clean” link between low-SES and school readiness, without adding additional linkages between low-SES parenting and Black families to the literature base. The study is beneficial for its emphasis on the non-ethnicity based socioeconomic variable on educational readiness and outcomes.

### *Language and Vocabulary Development*

Brooks-Gunn and Markman (2005) pointed out that young children's exposure to language and conversation varies by socioeconomic subgroup, or “social class.” There is a strong tendency for higher-SES parents to use more vocabulary words, engage in dialogue, ask questions, and discuss more topics than lower-SES parents when interacting with their children in the early years of their lives. Along with the increased use of language, there are unique speech cultures that exist alongside SES and race. The characteristics of the higher-SES speech cultures lead to increased conversational skills and vocabulary development in children. By the age of three, the vocabularies of children from low-SES groups have approximately half the vocabulary of children from higher-SES groups (Brooks-Gunn and Markman). Pugello et al. (2009) studied the effects of SES, race, and parent/child interaction on the language development of children ranging in age from 18-36 months. This research found that race was associated with receptive language ability, with Black children scoring lower on receptive language measures, and certain parental influences (maternal sensitivity and negative-intrusive parenting) were related to slower rates of language growth. In the area of expressive communication, race, SES, and maternal sensitivity were found to be significant for slower rates of expressive language growth. In a small study ( $n= 33$ ), Champion, Rosa-Lugo, Rivers, and McCabe (2010) found that

low-SES Black students in second and fourth grades with more pronounced African American dialects, as measured by the *Diagnostic Evaluation of Language Variation-Screening Test* (DELV-ST), were significantly more likely ( $p<.05$ ) to score lower on the reading comprehension subtest of the *Gray Oral Reading Test- Fourth Edition* (GORT-4). It should be noted, however, that the use of the GORT-4 to assess reading comprehension with validity has been a source of debate in the literature (Keenan & Betjemann, 2006). Additionally, as stated previously, consumers of research should be especially mindful about the tendency for SES and race to be conflated in the literature.

Horton-Ikard and Weismer (2007) examined the vocabulary development and word learning skills of young Black children ages 30-40 months in a small ( $n=30$ ) study. Interestingly, SES was the primary manipulated independent variable, as half of the participants were considered low-SES, and the other half as middle-SES. Three dependent measures of vocabulary development were administered to acquire a diverse sample of data. Standardized vocabulary tests, such as the *Peabody Picture Vocabulary Test* and the *Expressive Vocabulary Test*, were administered along with language sample measures that assessed “type-token ratios” and the number of different words used (NDW), and “fast mapping” language measures which include assessment of novel word learning. The results indicated that, on the standardized measures of vocabulary, the socioeconomically disadvantaged children performed significantly lower than the higher-SES students in receptive vocabulary ( $p<.01$ ) and expressive vocabulary ( $p<.001$ ). Statistically significant ( $p<.05$ ) differences between the two SES groups were also noted in the language sample measure; children from the middle-SES group used more words than their low-SES peers. On the fast mapping language assessments, it should be especially noted that there were no significant differences between the two participant groups. This means

that, in this study, SES was not found to be a significant variable when considering the children's ability to learn new word meanings and use them to interact with the examiner during the data collection. Again, we see in the literature that the *type* of assessment used to identify language “deficiencies” among diverse groups of children is called into question. The authors of the study point out that there is a tendency for performance on lexical semantic tasks to vary depending on the type of measure used, as this research demonstrates such an observation.

While there is ample evidence to relate race and SES to vocabulary and language development levels, there is surprisingly little research available on the effect of vocabulary/language level on specific academic achievement measures in at-risk populations. In an earlier study, Walker, Greenwood, Hart, and Carta (1994) researched the predictive effect of early language production and SES on various school outcomes. The small study ( $n=32$ ) was a follow-up study to a longitudinal project (Hart & Risley, 1989) that examined the relationship between family interaction and language learning in children 7-36 months of age. Using participants from the same families in the 1989 study, the researchers used a variety of standardized instruments (OLSAT, PPVT, TOLD, WRAT-R, etc.) to collect ability, language, and academic achievement data for a segment of now older (in 1994) 5-10 year old children. This information was obtained through the course of a school year, and was then compared to data collected when the children were 5 years younger. These variables included SES indicators, an assessment of intellectual ability (Stanford-Binet), and a measure of early language use in the home, to include cumulative number of unique words spoken and mean length of utterance (Hart & Risley, 1992). Using hierarchical regression, the early SES and language data was used to predict school outcomes for the children as 5-10 year olds. The researchers found that the students' SES predicted achievement on the school outcome measures. The predictive

relationship was strengthened when the early language use data was included as a variable alongside SES. These two variables had the most significant predictive relationship with receptive language, followed by spoken language, spelling achievement, reading achievement, and verbal ability, respectively. The findings not only reinforce previous research that supports the position that children from lower socioeconomic environments are less likely to have optimal language outcomes, but also strengthens the position that the factors influencing this phenomenon contribute to a decrease in academic readiness and achievement. However, the researchers were also appropriately vigilant in pointing out the disproportionate association between socioeconomic disadvantage and minority status, as race was not a variable considered in the study. They posit that the early language learning experiences of minority and socioeconomically disadvantaged children, while adaptive and valued in their homes and cultures, may not be conducive to “achievement” as conceptualized by the majority culture. This is one of the key debate points among scholars that currently study academic disparities in minority students.

In a recent position paper, Weddington (2010) addressed the topic of the achievement gap between minority and White students with respect to the assertion that disparities are born out of language differences. She insists that, while linguistic differences may have some bearing on student academic development and performance, they are only part of the larger picture. Weddington takes issue with the fact that analyses which isolate language as a key variable in achievement disparities do not also include teacher quality, instructional programming, and cultural sensitivity as factors that contribute to student achievement. Her paper cites examples in which students who have spoken “African American English” their entire lives succeeded in becoming high-achieving and productive learners. The arguments highlight an emphasis on

acknowledging students' heritage, and building a learning community that is accepting and inclusive of all families. Additionally, the author calls into question the assumption of an achievement gap in its own respect, and makes reference to potential testing bias which, according to her, more accurately represents a “test score gap” instead of a student achievement disparity. Weddington's primary point is that schools, teachers, and the learning community as a whole are the biggest influence on the academic success of Black students, and she does not endorse the position that language characteristics of the Black community are to blame for the education gaps we see today.

In contrast to Weddington's (2010) position, Dickinson, Golinkoff, and Hirsh-Pasek (2010) asserted that language is fundamental to reading development and early reading skills. In a critique of a report by the National Early Literacy Panel, the authors take issue with the Panel's meta-analysis research methodology in producing the report, which disproportionately emphasizes “code-based factors” of language over formative linguistic development, such as oral language and background knowledge. For example, the researchers are concerned that a report detailing these findings could be easily misinterpreted by educators, administrators, and policy makers as an endorsement to focus primarily (or solely) on letter knowledge, phonemic awareness, decoding, etc. when designing reading curriculum. They emphasize research supporting the critical importance of emergent language skills in the development of fundamental reading and comprehension skills when children begin school, and as they move through the elementary grades. While Dickinson, Golinkoff, and Hirsh-Pasek (2010) did not directly tie their position to the early language differences between Black and White students, they add credibility to the suggestion that ameliorating early language learning variances through the use of sophisticated vocabulary and analytic talk, as opposed to simply teaching reading

decoding skills, is an important factor in developing permanently ingrained literacy skills (Dickinson & Porche, 2011). The authors state that ignoring the importance of language “would be short sighted and would undermine the early and long-term reading abilities of the very children most in need of educational supports, those from low-income homes and from families who speak languages other than English at home” (P. 306).

The topic of language variances and dialects, and their influence on the achievement gap between minority and majority students, is not without discord and debate in the literature. Indeed, the suggestion that the use of African American English or “ebonics” may be a factor slowing Black students' adaptation to and utilization of Standard American English, the lexical format encountered in virtually all texts, seems to ignite controversy. This may be an area in which scientific study and cultural sensitivity will take longer to reconcile, as research findings that align culturally unique language patterns with lower achievement levels will likely find contradiction in smaller studies and case studies which prove that such findings are not necessarily generalizable.

### *Reading and Literacy Behaviors*

Another important factor that contributes to the achievement gap between Black/White and low-SES/higher-SES students is the lack of early exposure to literacy and literacy behaviors within the home and early childhood education settings. Indeed, parents reading to their children and reading as a socio-familial activity are considered to be important to the development of reading skills (International Reading Association, 2011). Several studies continue to emphasize early literacy experiences as a particularly essential protective factor for literacy development of socioeconomically disadvantaged children. As previously stated, these children represent a



disproportionate segment of the Black community and, consequently, results along racial lines can also be observed.

Rodriguez et al. (2009) researched the effects of literacy experiences within the home on language and cognitive ability during the first three years of life in 1,046 children from low-income families, who were part of the Early Head Start Research and Evaluation Project. Participants' literacy experiences were operationalized as the frequency of the children's engagement in literacy activities (mother/child shared book reading, storytelling, singing nursery rhymes), quality of maternal engagement (mother's sensitivity, stimulation of cognitive development), and provision of learning materials (accessibility of books, availability of toys which stimulate different developmental areas, such as music, hand-eye coordination, etc.). Language and cognitive ability were measured through standardized assessments such as the *Bayley Mental Development Index*, *MacArthur Communicative Developmental Inventory*, and the *Peabody Picture Vocabulary Test*; this data was collected from the children at 14, 24, and 36 months of age. Using bivariate correlations, the researchers tested for associations between child and family characteristics, and literacy experiences, language, and cognitive skills. Additionally, hierarchical multiple regression analyses were conducted to assess whether various aspects of the literacy environment predicted language and/or cognitive development in the participants. The results indicated that each of the broad literacy environment indicators were significantly related to the children's language and cognitive development at all three ages assessed. Demographic measures that predicted the quality of the literacy environment were maternal education, father's residency (within the home), and race/ethnicity. Interestingly, the study also found that maternal employment was positively associated with more highly rated literacy environment and language/cognitive outcomes. This finding alludes to the suggestion that increased economic

resources may have a more mediating effect on language/cognition than actual time spent with children in the home.

Similar studies have been conducted on low-income children's literacy experiences, with a focus on the actual *reading time* spent with children as a variable. The specific familial activity of mother-child book reading has been shown to have a positive impact on vocabulary, comprehension, and cognitive development in low-income children ages 14-24 months; this is especially true when reading occurs on a daily basis (Raikes et al., 2006). However, there has also been a growing interest in the effect of paternal involvement in literacy behaviors within the home. Duursma, Pan, and Raikes (2008) researched book reading engagement of fathers with their children from low-income backgrounds, and its predictive effect on their language and cognitive development using regression analysis. This study found that father/child shared book reading predicted children's cognitive outcomes at the  $p < .001$  level. Additionally, father-child book reading predicted language outcomes when the father possessed at least a high school education. Both Duursma, Pan, and Raikes (2008) and Raikes et al. (2006) found that White mothers and fathers were more likely to engage in shared book reading activities with their children than Black parents.

In a somewhat contradictory study, Roberts, Jurgens, and Burchinal (2005) researched the predictive effect of home literacy practices (operationalized as shared book reading frequency, maternal book reading strategies, child's enjoyment of reading, and maternal sensitivity) and the responsiveness of the home environment on children's early language and emergent literacy skills. The sample was comprised of 72 low-income Black children who were each enrolled in the study at less than one year old. A variety of data (questionnaires, interviews, observation, standardized achievement measures) were regularly collected over the course of approximately

four years concerning maternal reading strategies, maternal communication and sensitivity, home environment quality, and children's language and literacy development. While the study found moderate to large correlations among the use of positive literacy variables themselves (i.e. sensitive mothers tended to have children who enjoyed being read to), there were few significant relationships between home literacy practices and children's language and emergent literacy. The researchers, however, acknowledged that they did not control for demographic characteristics and other background factors, such as maternal education level, that may have further informed the interpretation of the results. Furthermore, there are some aspects of the data collection that pose limitations to the generalizability of the results. This study highlights the importance of solid research methodology and the use of valid, reliable, and vetted data collection methods and instruments.

The importance of exposure to literacy experiences is not something that is confined to the home environment. Indeed, it is just as important for socioeconomically disadvantaged children to be surrounded by reading-rich experiences in the early childhood education setting as well. In a 6-year longitudinal study, Zimmerman, Rodriguez, Rewey, and Heidemann (2008) researched the effectiveness of an enhanced reading program in Head Start classrooms entitled “Words Work,” (WW) which not only incorporates research-based effective pedagogies such as dialogic reading, oral language, print awareness, and early writing instruction, but also infuses parental participation and respect for differences in culture and language. A complex sample of 750 4-year old children were categorized into groups that were either exposed to the WW program, received traditional Head Start services, were on a “wait list” for Head Start services (non-treatment, non-Head Start), or were randomly selected to be part of a comparison group of typically developing peers in the same school district. The students were tracked

through their participation in the elementary school grades and were assessed yearly with the *Stanford Achievement Test-10*, and once in the first grade using the *Metropolitan Achievement Test-7*. Hierarchical linear modeling was used to assess the growth curve differences between the control (non-WW) groups and the treatment group (WW). Results indicated a statistically significant difference in the reading and math achievement scores between the treatment and non-treatment groups. Analyses did indicate an absence of a statistically significant increased growth rate for the treatment vs. non-treatment group. However, in spite of the lack of significant accelerated growth rate in reading and math, it should be noted that the treatment group's progress was commensurate with their typically developing peers and, in some cases, better than expected. This secondary finding emphasizes the importance of early intervention for low-income and disadvantaged students as a means to *prevent* an achievement gap from occurring.

Another recent study (MacDonald & Figueredo, 2010) examined a literacy intervention for low-SES kindergarten students in urban schools in central east Canada. Despite the international aspect of the study, the participants came from backgrounds with many of the same risk factors as those found in the United States, including economic deprivation and delayed oral language skills. The researchers studied the effectiveness of “The KELT Program” on oral language, print concepts, phonemic awareness, letter-sound knowledge, letter-sound correspondence, and word knowledge. KELT is an intensive, systematic instructional reading program that involves detailed attention to focus areas, instructional expectations, regular student assessment, and ongoing professional development. In addition to addressing reading skills through direct instruction, KELT also contains a tutoring component to remediate areas of concern. KELT was implemented over the course of an entire school year. Using simple pre-

test/post-test design, the study found that KELT implementation was significant for positive gains in concepts of print ( $p<.01$ ), phonemic awareness ( $p<.05$ ), letter-sound knowledge ( $p<.01$ ), and word knowledge ( $p<.01$ ) when compared to students who did not receive KELT. The key component of this study that should be recognized is the dedication of resources to the prevention of an educational disparity that may actually be more expensive and exhaustive to ameliorate after it has occurred. While the KELT study is fairly simple in design, it highlights the positive impact of a structured reading program with built in additional support that, while more costly, should be seen as an investment in establishing and maintaining equity in education.

Examination of the factors that have a general impact on academic achievement, readiness, and educational attainment is important in understanding the multi-dimensionality of the achievement gap that exists between Black and White students, and low SES and middle/higher SES students. Most of the studies referenced to this point offer a broad view of the effects of parental influence, language development, and reading/literacy behaviors on students' readiness to learn and their general academic progress. The research examined thus far is also primarily related to language and reading readiness, as there were multiple studies evaluating these domains. It has been discussed, however, that mathematics is also an area in which disparities in knowledge and readiness also continue to be observed. There is disproportionately less research on the origins of the math achievement gap, despite its existence as a primary concern in fostering educational equity for students of diverse ethnic and socioeconomic backgrounds.

### **The Mathematics Achievement Gap**

Up to this point, the current literature review has focused on the achievement gap

between Black and White students, and lower-SES and higher-SES students, in general terms; attention has been given to academic readiness skills, many of which revolved around language and reading. However, as noted in the literature and NAEP data, mathematics is an area of concern regarding educational disparities. Eddy and Easton-Brooks (2011) pointed out that the math achievement of Black students may be a more problematic issue to address than reading and language, as the cultural opportunity to learn math in the home environment (as opposed to learning to speak and function linguistically in a culturally relevant context) is diminished. Recent studies focus on mathematics achievement disparities within the framework of early cognitive development, teacher factors, and curriculum and instructional programming for historically underserved students, in addition to already documented socioeconomic factors contributing to the gap.

Cooper and Schleser (2006) researched the relationship of cognitive developmental levels to mathematics achievement between Black and White students in kindergarten and first grade. In this simple study, SES was controlled for, as none of the participants were considered economically disadvantaged by their school system. A total of 58 students (26 kindergartners, 30 first graders; 40 White students, 16 Black students) were included in the study; the mean age for the White children was 6.28, and 6.24 for Black children. The participants' cognitive development level was assessed by completion of two "Conservation of Number" tasks, and one "Conservation of Substance" task. Scoring rubrics from these tasks were developed using Piaget's theory of intellectual development, specifically assessing participant placement on a continuum ranging from pre-operational at the lowest level and concrete operational at the highest level, with transitional development occurring in the middle of the two extremes. Mathematics achievement was measured through the administration of the calculation, fluency,

and applied problems subtests of the *Woodcock-Johnson Tests of Achievement 3* to obtain a Broad Math score. The data was analyzed using independent samples *t*-tests and revealed statistically significant differences in mathematics achievement in the areas of math fluency ( $p<.01$ ) and applied problems ( $p<.001$ ). Additional analyses concerning cognitive development level indicated that more Black students were functioning on a pre-operational level (62.5%) versus White students (32.5%); these results were also statistically significant. Analyses determining a correlation between cognitive developmental level and broad math achievement revealed a significant but modest relationship ( $p=.05$ ). Finally, analysis of co-variance (ANCOVA) showed that broad math achievement and race were *not* significantly related to each other when cognitive developmental level was controlled for, suggesting that cognitive developmental level mediates the relationship between mathematics achievement and race. There were, however, obvious limitations to the study. These limitations included the small *n* count, especially in the Black student participant numbers, and the apparently non-scientific dependent measure that gauged cognitive development level. This study suggests that cognitive developmental level could be related to race and mathematics achievement, but this should be interpreted with caution. Other investigators have tended to focus on specific mathematics intervention and other initiatives when researching math achievement disparities.

In an experimental study, Klein, Starkey, Clements, Sarama, and Iyer (2008) examined the effectiveness of a mathematics instructional intervention for pre-kindergarten students attending Head Start and state-run preschool classes in California and New York. Participating Head Start and state preschool sites were randomly assigned for either implementation of the *Pre-K Mathematics* curriculum program and DLM Express mathematics software, or utilization of existing mathematics curriculum for students. Eight students were randomly selected from

each site to collect pre-test and post-test data, bringing the total sample size to 278. In addition to the administration of parent questionnaires concerning home environment and collection of teacher observation data, the selected participants' mathematics knowledge was assessed by the *Child Math Assessment* at the beginning and end of the school year; no significant achievement differences were noted in baseline data between the control and experimental groups after the pre-test. As part of the routine data collection procedure for all students participating in the pre-K program, other information was collected during the course of the school year using instruments such as the *Woodcock-Johnson Tests of Achievement*, *Preschool Comprehensive Test of Phonologic and Print Processing*, *Test of Language Development*, *Peabody Picture Vocabulary Test*, and the *Test of Early Reading Ability*. Ongoing professional development was provided to the teachers in the experimental group, which included multiple training workshops, coaching from program facilitators, and observation with feedback given. Multiple steps were taken to ensure that the intervention was implemented with fidelity, including analysis of data taken by facilitators during the course of the year. At the end of the school year, the study found that children in the experimental group performed significantly better ( $p < .0001$ ) on the *Child Math Assessment* than the control group. Using the cross-program routine battery of tests, a mathematics achievement composite score was derived from the applied problems subtest of the *Woodcock-Johnson*, the “shape composition” task, and a separate abbreviated form of the *Child Math Assessment*. Students' math knowledge from the experimental group was again significantly higher than that of the students from the control group ( $p < .01$ ). It should also be noted that neither the experimental nor control group differed in their pre-test/post-test measures concerning language development, vocabulary, and early literacy skills, which bolsters the math-specific validity of the research. This study was a very strong, robust investigation on the effects



of math intervention for low-income preschool children. Despite the background factors, achievement gaps in mathematics can be prevented if solid instructional practices are begun early.

Another study conducted by Mac Iver and Mac Iver (2009) examined the effect of a mathematics curriculum initiative under “whole school-reform” models for urban middle schools in Pennsylvania. Specifically, high poverty schools in Philadelphia began the process of adopting reform models during the late 1990s. The adoption of mathematics curriculums which incorporate National Council of Teachers of Mathematics (NCTM) standards, fostering smaller learning communities, and using research-based math programs sanctioned by the federal What Works Clearinghouse (WWC) were some of the characteristics of these reform efforts. In an analysis of Pennsylvania System of School Assessments (PSSA) data, the state's current standardized annual testing program, the researchers sought to identify relationships between schools' reform efforts and increased mathematics achievement. In particular, the study aimed to distinguish math intensive curriculum reform from standard whole school reform methods, and compare math achievement data between the two groups. The study found that math-specific reform efforts which utilized research-based programs had a statistically significant positive impact on student math achievement when compared to the general school reform models examined ( $p < .001$ ). Furthermore, the number of years that the schools had been undertaking mathematics reform efforts was positively and significantly related to math scores on the PSSA. Additional analyses of content cluster specific achievement gains related to math curriculum reforms were also noted, and the benefits of math achievement data analysis by content strand such as this will be discussed in the next section of this literature review.

In both of the two previous studies, there is an emphasis on analyzing mathematics

curriculum with respect to closing the achievement gap. However, other recent studies have examined teacher variables, such as instructional techniques and teacher quality, as potential variables in understanding and narrowing the disparity. Georges and Pallas (2010) researched the relationship between math achievement gaps by race and SES and teaching practices using ECLS-K data. The researchers hypothesized that student achievement gaps along racial and socioeconomic lines would narrow significantly when their teachers used advanced methodologies which emphasized higher order understanding, such as problem-solving and student perspective incorporation into instruction, versus teaching techniques that were based on rote memorization and drill/practice. The methodology included a three-level growth curve model which tracked students' growth trajectory, detailed variations in growth among students' within a school, and also measured growth variations among schools themselves. Mathematics knowledge differences during the summer months were also estimated in addition to growth during the school year. It is quite interesting that the study found no significant differences in student mathematics outcomes when teaching practice was used as the independent variable. When SES was incorporated as a variable, the researchers found no significant narrowing of the achievement gap with teaching practice as the independent variable. The authors noted that low-SES students tended to fall behind in advanced mathematical knowledge faster than their higher-SES peers. This trend also applied to Black and Latino versus White students. While Black and Latino students had higher skill growth rates in certain content area subtests of the mathematics data, these were not considered significantly different than those gains made by White students, who progressed more rapidly in higher-level math skills. An important secondary finding, however, involved teaching practices and learning retention during the summer months. Teaching methodologies that involved focus on analytical and reasoning skills had a modestly

significant impact on mathematics achievement among low-SES students. In summary, the investigators failed to reject their null hypothesis, as mathematics teaching practices were generally not found to be significantly related to kindergarten students' math knowledge by race and SES. Limitations, such as differences in the alignment of teaching practices from the specific data used by the ECLS-K and the ability of kindergarten math skill data to be a reliable estimate of “mathematics achievement,” were discussed in the study.

In a complex study, Desmione and Long (2010) investigated the relationship of teacher quality, operationalized as degree held, teaching experience, certification in math, etc., to math achievement. As in Georges and Pallas (2010), ECLS-K data was used to establish the variables, which included SES and race. Composite variables representing teacher characteristics were also created to quantify teacher quality, which included formal education, experience, and professional development, and instructional methods, which was derived from the time spent on various mathematics skills relative to their complexity level. The researchers used hierarchical linear modeling to analyze the data, which included math scores and covariates in the first level, student factors such as SES and race in the second level, and the teacher variables in the third level. Dense analyses of the variables yielded some noteworthy results. For example, the distribution of teachers with varying levels of education, experience, certification, and professional development was equally divided among all students, even when race and SES were considered. This means that access to a “high quality” teacher did not differ significantly among the sample, regardless of race and SES. Additionally, the amount of time spent on math instruction at different levels of complexity relative to mathematics achievement was not significantly different in any of the sample subgroups. These findings are also reminiscent of those described by Georges and Pallas (2010). However, the study did reveal that initially lower

achieving students tend to be assigned to teachers who use instructional methods of less complexity, and initially higher achieving students are assigned to teachers who emphasize more advanced conceptual approaches to teaching math. There was also an identified relationship between teachers that used more advanced conceptual approaches and an accelerated achievement growth rate for the students. This finding is, however, tied by default to the previous finding that higher achieving students tend to be placed with these teachers anyway. Finally, there was a significant relationship between the amount of time spent on mathematics instruction and achievement levels in both Black and socioeconomically disadvantaged students in the first grade cohort. Perhaps the most important result of the study is exposure of the fact that the weakest math students tend to get math teachers that emphasize the least complex learning strategies, despite the consistency of “high quality teachers” that instruct the students. This trend of poorly performing students receiving teachers that only instruct at basic levels is an issue that has been identified in the literature (Smith, Desimone, & Ueno, 2005; Ladson-Billings, 1997). Nevertheless, it is interesting that these recent studies have suggested less of a connection between the racial and socioeconomic achievement gap in math and specific teacher characteristics and practices within the classroom.

There have been recent more non-traditional explanations for the mathematics achievement gap in Black students. For example, cultural context and experiences that Black children have in schools in relation to their math achievement has been studied. Students in schools with a lower-SES average population have decreased achievement, and because of the concurrent relationship between economic disadvantage and race, Black students fair worse in these schools (Brown-Jeffy, 2009). Another factor in the math achievement of Black students is ethnic matching of teachers and their pupils. Dee (2004) found that Black students tend to

perform higher on reading and mathematics measures when they were taught by a Black teacher. Eddy and Easton-Brooks (2011) studied this more extensively, comparing the ethnic matching of students and teachers in at least one elementary school year with the results of math achievement using ECLS K-5 data. These students' math growth rates through their elementary school years were also calculated. The study found that matching teacher ethnicity was significantly related to higher mathematics achievement, and that achievement gaps between Black students with Black teachers and Black students with White teachers increased significantly each year. Similar to Brown-Jeffy (2009), the study also found that students in schools with higher numbers of minorities in general tended to score lower than minority students in schools whose population is predominantly non-minority. The authors cautioned against drawing a causal interpretation of the findings. However, the findings do support the position of Weddington (2010) on the importance of cultural connectedness in students' school experiences.

### *Mathematics Achievement Gap Trends Over Time*

The persistence of widening achievement disparities through students' years of schooling has been shown to be a barrier in attempts to ameliorate the problem of knowledge gaps. This phenomenon is present when one examines literature related not only to achievement gaps related to ethnicity, but overall for students in general as well. As Condrón (2009) points out, the formation and pervasiveness of achievement disparities are multi-faceted and developmental, with influences occurring both before formal education ever begins and during the first years of schooling. Available research on the mathematics achievement gaps as students progress through school seems equally multi-dimensional, depending on the measure utilized and circumstances of the populations studied. In fact, differences in analytical methods, sample

characteristics, and metrics used often lead to conflicting information on the evolution of the achievement gap (Reardon & Robinson, 2007).

Burchinal et al. (2011) notes that achievement gaps between Black and White students can be observed as early as the age of three, with familial factors, child care experiences, and schooling/instructional quality being strongly related to the disparities. By kindergarten, disparities in mathematics achievement are initially measured at approximately three-quarters of one standard deviation, with Black students losing comparatively more ground over the first two years of school than students of other ethnicities (Fryer & Levitt, 2004). However, when studying ECLS data but utilizing a different statistical analysis method [quantile version of the Oaxaca-Blinder decomposition method], Sohn (2012) found that the gap is initially disproportionate in different parts of the data distribution, and does not grow at the same rate as students progress in school. Additionally factored into the analysis were identified “attributable differences” in both amount and effect of sample characteristics, which leads the researcher to declare that the “gap across quantiles evolves in a more complex way than the mean gap can ever reveal” (P. 176). Referencing ECLS K-5 data, Reardon & Robinson (2007) observe that the achievement gap between black and white students widens to about one standard deviation in between the first through fifth grades. Other research using different data sets have reached different conclusions.

Evidence of the questions surrounding the true manner in which the achievement gap evolves during a student’s school career can be seen in an earlier study by Phillips, Crouse, & Ralph (1998). The researchers used data collected from 1991-1993 as part of the Prospects study. Their analyses indicated that mathematics achievement gaps grow significantly from first to second grade, and from seventh to ninth grade. Conversely, no significant gap growth was

noted from third to fifth grade. This contradicts more contemporary research cited previously in this dissertation, and perhaps leads one to question what factors may contribute to findings that are in contrast to research conducted approximately one decade later. Another study by Murnane, Willett, Bub, and McCartney (2006) utilized Woodcock-Johnson assessment data obtained by the National Institute of Child Health and Human Development as part of the Study of Early Child Care and Youth Development (SECCYD). This research revealed that mathematics achievement gaps between Black and White students actually narrowed from kindergarten to third grade. The investigators did, however, advise consumers to interpret the results with caution, as the Woodcock-Johnson Tests of Achievement report broad achievement levels; other data sources could have provided more detailed information, and a potentially more accurate picture.

Research conducted on Black and White students from different areas of the country and in contrasting curriculum exposure situations (by state) has also been noted to produce conflicting information about the mathematics achievement gap. For example, Reardon & Robinson (2007) described two unpublished math gap analyses that were conducted in North Carolina and Texas from data obtained in the mid-late 1990s. While the achievement gap in North Carolina did not fluctuate for students in third through eighth grades, there was a modest growth in the gap for third through eighth grade students in Texas. Because the students were from different states, there are natural questions about the relationship between the exposure to the specific mathematics curriculum, education system efficacy, instructional practices, etc. and the presence or absence of an achievement gap between black and white students.

Examination of the literature and knowledge base on critical factors related specifically to the mathematics achievement gap between Black and White, and low socioeconomic and higher socioeconomic students, does not reveal a direct link. In many ways, the literature produces more questions than answers about student variables, effective policy, and best practices in teaching and math curriculum. One aspect of the literature that is not addressed is the lack of concept-specific detail when mathematics achievement data was examined as a dependent variable in the research. Specifically, summative and/or broad math scores tend to be used when evaluating the effect(s) of independent variables. This may lead one to wonder what further information may be obtained by looking inside the mathematics achievement gap and examining the details within.

### **The “Gaps Within the Gap”**

In returning to the discussion on the mathematics achievement disparities demonstrated in NAEP data, it is noteworthy that the variety of adverse influences in the lives of underserved students can be observed quantitatively when one compares their performance with more advantaged students. This phenomenon has historical underpinnings, as well as influences of modern life and society, that complicate efforts (and, in some cases, the efforts are *modest*) to truly ameliorate the disparity, as opposed to simply “apply a bandage.” It is true that achievement for Black students has improved since the early days of NAEP measurement, and that mathematics achievement discrepancies in terms of Black vs. White students have narrowed. However, the narrowing of the math achievement gap in NAEP data has rarely been statistically significant. Mathematics achievement improvements have mainly occurred within the context of basic skill development. Additionally, the achievement gap actually widens as math skill



complexity increases. Due to the tendency for teachers that instruct at-risk students, including students from different socioeconomic classes, race, and disability levels, at lower cognitive levels (Anyon, 1981; Ladson-Billings, 1997), it is a distinct possibility that Black students and socioeconomically disadvantaged students have not been receiving mathematics instruction that reflects the stimulation and development of higher order thinking skills supported by the NCTM (Johnson & Kristonis, 2010). To obtain a better understanding of content-specific skill discrepancies within mathematics achievement data, it is important to analyze detailed information collected on students' math achievement levels.

There are very few studies that examine the mathematics achievement gap along content strands and complexity levels. One of the more recent studies (Lubienski & Crockett, 2007) revealed some noteworthy details. Using 2003 NAEP data, the researchers examined math achievement along racial/ethnic and socioeconomic lines, in addition to student affect and school/home factors. This was the first year that NAEP collected individual state samples of achievement data, which increased the representative sample size to over 150,000 students across the country in grades 4 and 8, and allowed for the incorporation of all the primary racial categories into the data analysis. In addition to describing the general achievement trends from 1990 to 2003, the study also examined student performance information by mathematic content strand from the 2003 NAEP math administration. A previous study (Strutchens, Lubienski, McGraw, & Westbook, 2004) documented mathematics achievement disparity trends by race in NAEP data from 1990-2000, and revealed that the content strands of “measurement” and “data analysis” had the highest level of disproportionality between White and Black students. Lubienski and Crockett's (2007) study revealed the same finding in their analysis. Interestingly, these were the only two content strands in which White students outscored students identified as

Asian/Pacific Islander (PI); Asian/PI students achieved the highest in all other content areas. The “measurement” strand revealed particularly problematic achievement disparities between Black and White students, with the gap existing at 33 points in 4<sup>th</sup> grade and an alarming 50 points at 8<sup>th</sup> grade. To understand the nature of this phenomenon, the researchers conducted a test item analysis to pinpoint test questions with the largest disparities.

Item analysis at the fourth grade indicated difficulty with multi-step problems and understanding terminology used in prompting a computation operation (i.e. “all together” means adding, “difference” means subtracting, etc.). It is quite interesting that, on test items which included stand-alone computation problems (i.e.  $238+462=?$ ), the great majority of students in *all* subgroups answered correctly. In this item analysis, it can be interpreted that the issue is not with computation skills, but with the need to receive explicit instruction on using operational terminology to complete more advanced problems. Additionally, the researchers conducted an answer “decoy analysis” on test items with disproportionately high discrepancies to assist in understanding the mental processes students were using (or not using) in attempting to answer the questions. In eighth grade, Black students had disproportionate difficulty with items involving algebra, data analysis, and geometry. Patterns of conceptual, but not procedural, misunderstanding in Black students were similar to those noted in the fourth grade item analysis. For example, when Black eighth grade students were asked to make a mark where  $\frac{3}{4}$  would exist on a number line given the points 0,  $\frac{1}{2}$ , and 1, only 45% of Black students answered correctly as opposed to 72% of White students. However, when presented with an item requiring students to choose the figure that was  $\frac{3}{4}$  shaded, over 90% of Black students answered correctly. Decoy analysis also indicated the tendency for Black students to be tricked into answering only the first step of a multi-step problem, thus reinforcing the need for instructional focus on answering

multi-step problems strategically. The authors conclude by noting the discrepancies involving mathematical process and non-routine problems, and positing that at-risk students could be receiving less of the emphasis on the kind of conceptual understanding and complex problem solving that is sanctioned by NCTM (Lubienski & Crockett, 2007) .

Not all mathematics education researchers are in agreement that mathematics achievement gap analyses are needed, or even an appropriate method of representing true student knowledge and understanding of math. In a position paper, Gutierrez (2008) argued against mathematics achievement gap research, which she terms is part of a “gap gazing’ fetish,” on the basis of several assertions. First, she points out that analyses which document the mere existence of an achievement gap along selected demographic lines are all but useless, a position that has a fair degree of merit. This type of inquiry has the potential to lead to an unconscious acceptance of the achievement gap as universal truth, unable to be influenced. Additionally, the author takes issue with achievement research that inherently relies on the comparison of two or more groups, usually White and any variation of non-White or lower class. She claims that this brand of research further engrains the notion of White middle-to-upper class as the benchmarking standard of existence, and other races/classes of people as “deviant.” Gutierrez argues that mathematics achievement gap research that is strictly quantitative in nature lends false credibility to the suggestion that the problem is a technical one, instead of larger issues of learning, equity, and mathematical literacy that can be applied to the lives and experiences of students in a diverse society. In conclusion, she calls on research in mathematics education to place more emphasis on effective teaching and learning environments, making these environments accessible to teachers and practitioners, and focus on specific interventions.

Williams and Lemons-Smith (2009) offered a few reinforcements to Gutierrez' (2008)

points. In another position paper, they claim that achievement gap research in mathematics emphasizes points from “deficit perspectives.” The authors cite research and policies that, like Gutierrez, is reminiscent of accepting the achievement gap as unmovable truth, as much of it is focused on *reducing* the gap rather than *eliminating* it. Due to the historical background associated with educational disparities, it is suggested that the achievement gap is more an issue of civil rights and social justice. The authors posit that the real gap is a “quality of service” gap, in terms of the restructuring of resources and shifting of paradigms about people from diverse cultures and backgrounds that must occur. At the conclusion of the essay, there is a call for mathematics researchers and educators to “direct their gaze away from the achievement gap and toward the inequities inherent in the limited access to quality science and mathematics education that has existed for students of color in our country” (P. 27).

In contrast to the positions stated above, Lubienski (2008) argued that research on mathematics achievement gaps is crucial and essential to ameliorating the problems that the two former researchers cite. Specifically, she called for detailed gap analyses that, like Guterrez (2008) and Williams and Lemons-Smith (2009) support, goes beyond the mere identification of a math achievement gap. Rather than state positions in the direction of inequity, Lubienski articulates how mathematics gap analyses are an important component in influencing public opinion and the development of educational policy. For example, research that focuses on achievement gap acts as a rebuttal for other studies, conducted by researchers outside of the field of education, who insist that monetary resources, class sizes, etc. do not matter. It also acts as a buffer between true scientific study and mathematics “research” that is geared toward advancing political agendas (i.e. any study from The Heritage Foundation). Solid quantitative research on mathematics achievement gaps have a stronger effect on countering forces that attempt to shift

the “climate of opinion” in our current environment of instantaneous media and sound bytes. Another point made by Lubienski is the benefit of math gap research that analyses the “gaps within the gap.” Citing the study examined earlier in this literature review (Lubienski & Crockett, 2007), she noted the relative difficulties for Black students with mathematical concepts in the measurement strand of the 2003 NAEP assessment. If nothing else, this information offers a beneficial narrow-lens glimpse into an area that needs instructional attention and intervention on conceptual understanding. “Such information about which groups, item types, and mathematical topics are most in need of targeting is important for mathematics educators to draw from as they design equity-focused interventions” (P. 354). To summarize, Lubienski supports work that furthers educational equity for traditionally underserved students, but believes that mathematics gap analyses research should accompany this agenda as supporting documentation in not only addressing factors that cause achievement disparities, but also creating a full understanding of the disparities themselves.

## Chapter 3

### Methodology

Given the need for detailed mathematics achievement gap analysis for historically underserved populations revealed in the literature, the current study seeks not only to identify the achievement gap between Black and White students, and socioeconomically disadvantaged and advantaged students, but also to explore the mathematical content areas in which individual math skill disparities are significant along those demographic lines. The following research questions are relevant to the investigation:

1. When controlling for student gender and disability status, is there a statistically and/or practically significant difference in overall mathematics achievement between Black and White students at elementary and middle school levels on the Virginia Math SOL Assessment?

Hypothesis: A statistically and practically significant difference in overall mathematics achievement scores between Black and White students will be indicated in the data analysis.

2. When controlling for student gender and disability status, is there a statistically and/or practically significant difference in overall mathematics achievement between socioeconomically disadvantaged and advantaged students at elementary and middle school levels on the Virginia Math SOL Assessment?

Hypothesis: A statistically and practically significant difference in overall

mathematics achievement scores between Black and White students will be indicated in the data analysis.

3. When controlling for student gender and disability status, is there a statistically and/or practically significant difference in strand-based mathematics achievement between Black and White students at elementary and middle school levels on the Virginia Math SOL Assessment?
4. When controlling for student gender and disability status, is there a statistically and/or practically significant difference in strand-based mathematics achievement between socioeconomically disadvantaged and advantaged students at elementary and middle school levels on the Virginia Math SOL Assessment?
5. When controlling for student gender and disability status, is there an interaction between race, socioeconomic status, and school levels as independent variables in overall and strand-based mathematics achievement on the Virginia Math SOL Assessment?

### *Type of Study*

The current inquiry is a non-experimental descriptive study of existing elementary and middle school mathematics assessment data concerning overall and strand-based mathematics achievement disparities between Black and White students, and socioeconomically disadvantaged and advantaged students, in a large and diverse school district in Central Virginia.

### *Selection of School District*

The participating school district, hereafter referred to as “School District A,” was selected because of the student population diversity and relative similarity to the makeup of the Virginia student population as a whole. Additionally, the researcher’s familiarity with the student population, demographic profile, and the researcher’s employment with the school district were convenience factors in soliciting the participation of School District A.

According to the 2010 Census Report, the state of Virginia reported a total population of 8,001,024. The population of the county served by School District A, hereafter referred to as County A, accounts for 3.8% of the population of the state. More specifically, children under 18 years of age make up 24.2% of the entire population of County A; this is similar to the state of Virginia, which reported 23.2% of the population as under 18 years old. When considering County A as a whole, Black citizens comprise 29.5% of the population, and White citizens make up 59.2%. However, disproportionality exists between Black and White populations within County A when the racial makeup of different communities within the locality is accounted for.

County A is divided into 5 magisterial districts, hereafter referred to as District 1, District 2, etc; each of the magisterial districts is served by School District A. In two of the magisterial districts (District 2 and District 4), Black people comprise the majority of the population. The Black population of District 2 and District 4 is 63.8% and 51.9%, respectively. The schools in these districts also educate a substantial majority of students in the county that receive free/reduced price lunch, and are thereby considered low-SES. The other magisterial districts served by School District A, while diverse, contain a much lower ratio of Black citizens to other citizens (District 1= 19.3% Black, District 3= 8.6% Black, District 5= 8.3% Black).



Equitable distribution of resources has been a continuing conversation within School District A. Historically, the schools within District 2 and District 4 have struggled to keep pace with student achievement in comparison to schools within the other districts. Other factors, such as disproportionate use of discipline procedures for Black students vs. White students and overrepresentation of Black students in special education, have also been noted. The combination of these elements, and the economic and educational disparities among districts being served by the same school system, poses a unique challenge for School District A. Achieving a need-based balance in the way teachers are assigned, funds are allocated, administrators are hired, resources are distributed, etc. has been a focus of the community for some time, particularly in Districts 2 and 4.

### *Selection of Data Source*

Achievement data over the course of three academic years (2009, 2010, and 2011) were analyzed to determine significant differences in overall and strand-based performance between and among the identified subgroups in Grades 3-8. Effect size was also calculated to identify practical significance of any statistically variance noted. Mathematics achievement data from the 2012 academic year was, however, excluded from the study for various reasons.

In 2009, the Virginia Board of Education adopted new K-12 Standards of Learning for Mathematics; previous mathematics SOLs had not been revised since 2001. These revisions were part of an effort to promote college and career readiness, and to align Virginia's math standards with the Common Core State Standards for mathematics (VA DOE, 2012). School districts across the state were given discretion concerning the best way to implement these new standards, including how quickly to introduce them, whether to phase the standards in at various

times during the year for different grade levels, etc. However, students in Virginia would not be assessed on the new 2009 mathematics standards until 2012.

This researcher chose to analyze achievement data from the 2009, 2010, and 2011 mathematics assessment administrations for two primary reasons. First, the assessments from these years reflect student mathematics achievement based upon consistent exposure to the adopted Virginia math curriculum in place since 2001. The researcher acknowledges that students in grades 3-8 will have been receiving instruction based upon a revised and more rigorous mathematics curriculum by the time this study is completed and published. This fact, however, relates to the second reason for the selection of the assessment years.

Mathematics SOL assessment results from the 2012 administration were released in August 2012. Student performance in grades 3-8 reflected the implementation of a new, more rigorous curriculum to which they had not been exposed to in the previous 9 years. Math scores across the state of Virginia fell dramatically from previous years as students experienced the realignment of the mathematics SOL assessment as well. This phenomenon was experienced in school districts in Central Virginia as well, including School District A, and was anticipated by the Virginia Department of Education (Reid, 2012). If the data from the 2012 mathematics assessment administration were included in the current study, results obtained would almost certainly be confounded by this phenomenon. The assessment years of 2009, 2010, and 2011 reflect the most consistent math performance available for students in Virginia at the time of publication of this study. However, the researcher does acknowledge that future data analysis and research will be an important element in continuing to understand mathematics achievement gaps, especially as they relate to the newly adopted mathematics curriculum in Virginia moving forward.

### *Population and Sampling*

As of 2012, the State of Virginia enrolled over 1,258,000 students in all its public schools. Over the course of three academic years from 2008-09 to 2010-11, the student population in Virginia has remained relatively stable, with marginal increases noted in each school year. During the 2008-2009 school year, the total student population was 1,235,064. In 2009-2010, the student population was 1,244,673. During the 2010-2011 school year, the student population was 1,251,949. In all three academic years, Black and White students comprised the majority of students served in Virginia public school systems (approximately 80%). During the same time frame, School District A enrolled over 48,000 students in Central Virginia. For the 2008-2009 school year, the total student population was 49,407. In 2009-2010, the student population was 48,509. During the 2010-2011 school year, the student population was 48,431. Together, Black and White students comprised the majority of the student population count in each of the three academic years (approximately 82%). However, it should be noted that School District A enrolls comparatively more Black students, and less White students, than the state as a whole. With respect to students from economically deprived households, the State of Virginia currently enrolls over 465,000 students considered socioeconomically disadvantaged. School District A enrolls approximately 18,000 socioeconomically disadvantaged students. In terms of percentages of socioeconomically disadvantaged students compared to total student enrollment, School District A is similar to Virginia. The reader is referred to *Table 1* for a comparative breakdown of Black and White, and socioeconomically disadvantaged student enrollment in Virginia and School District A.

Table 1

*Student Membership by Ethnicity and Socioeconomic Status- State of Virginia*

2008-2009 School Year					
	Total Student Population	Black Student Enrollment	White Student Enrollment	“Other” Student Enrollment	Disadvantaged (Low-SES) Enrollment
State of Virginia	1,235,064	317,151 (26%)	698,465 (57%)	219,448 (17%)	398,885 (32%)
“School Division A”	49,407	18,211 (37%)	22,353 (45%)	8,843 (18%)	12,792 (26%)
2009-2010 School Year					
State of Virginia	1,244,673	316,471 (25%)	697,326 (56%)	230,876 (19%)	410,215 (33%)
“School Division A”	48,509	17,765 (37%)	22,087 (46%)	8,657 (17%)	15,367 (32%)
2010-2011 School Year					
State of Virginia	1,251,949	301,170 (24%)	677,767 (54%)	273,012 (22%)	445,261 (36%)
“School Division A”	48,431	18,020 (37%)	22,267 (46%)	8,144 (17%)	15,613 (32%)

Source: Virginia Department of Education Fall Membership Report

\* “Other” includes the race categories of Asian, Hispanic, American Indian/Alaska Native, Native Hawaiian/Pacific Islander, and Multi-Racial.

*Definition of Variables*

Based on the research questions, the three independent variables are **race**, **socioeconomic status**, and **school level**. Race is a dichotomous categorical independent variable, as students are identified as either “White” or “Black” in the data set. Because the current research is solely concerned with the mathematics achievement gap between Black and White students, students

belonging to other racial categories are not included in the study. In the State of Virginia, Black and White students together comprise roughly 80% of the entire student population over the three-year time span. In School District A, the figure is similar at approximately 82%.

Socioeconomic status is a dichotomous categorical independent variable. Based upon the operational definition of “socioeconomically disadvantaged” (see *Chapter 1*, Definition of Terms), students are classified as either receiving free/reduced price lunch (low-SES) or regular priced lunch (high-SES). In both the State of Virginia and School District A, the free/reduced price lunch indicator is used to classify students considered socioeconomically disadvantaged. This study utilizes the same indicator to group students for the purpose of identifying statistical/practical significance in math achievement between socioeconomically disadvantaged and non-disadvantaged students. Finally, school level is a dichotomous categorical independent variable. Students classified as “elementary school” level completed mathematics tests in Grades 3, 4, and 5. “Middle school” level data applies to mathematics tests in Grades 6, 7, and 8.

The dependent variables in the current study are **overall mathematics achievement** and **strand-based mathematics achievement**. Overall mathematics achievement is a continuous variable represented by the student's total scaled score on the Virginia Mathematics SOL. Total scaled scores range from 0-600, with 400 being the pass/fail benchmark, and 500 being the benchmark for general proficiency/advanced proficiency; 600 is a perfect score. Strand-based mathematics achievement is a continuous variable that represents a student's proficiency in the five conceptual mathematics areas, or reporting categories (RCs), assessed by the SOL (see *Chapter 1*, Definition of Terms). RC scaled scores range from 0-50, with 32 being the non-proficient/proficient benchmark in each respective conceptual area. These scores are calculated

by factoring the student's raw score with the weight and taxonomic complexity of each question. For more information on the formulas used to calculate scaled scores from raw scores in mathematics RCs, the reader may visit the Assessment and Reporting webpage located on the Virginia Department of Education website (<http://www.doe.virginia.gov>).

### *Instrumentation*

The instrument used to quantify both overall and strand-based mathematics achievement is the Virginia SOL Mathematics Assessment administered in the Spring of 2009, 2010, and 2011. This assessment has been found to be a consistently valid and reliable criterion-referenced measure of student knowledge of the Virginia mathematics curriculum. The most recent technical analysis of the Virginia SOL assessment established internal consistency among test items in all subjects at Grades 3-8 using *Cronbach's Coefficient Alpha*. Internal consistency coefficient values range from 0.0 to 1.0, with zero demonstrating no consistent relationship among test questions, and 1 demonstrating a perfect relationship among test questions. *Alpha* coefficients that exceed .70 demonstrate test items that are internally consistent (Mitchell & Jolley, 2010). On the Virginia Mathematics SOL assessments at Grades 3-8, *Alpha* coefficients ranged from .87 to .91 for the online administrations, and .87 to .93 for the paper administrations. Construct validity was established by comparing math test items at Grades 3, 5, 8, and 11 with conceptually similar math questions on the *Stanford 9 Assessment*. Correlation coefficient values from this analysis were: Grade 3= .72; Grade 5= .76; Grade 8= .82; and Grade 11= .71 (Virginia Department of Education, 2009).

### *Data Files and Collection*

The Virginia Department of Education, in collaboration with Pearson Education Inc., produces a comprehensive data file annually after testing and post-testing adjustments have concluded. This data file contains information pertaining to all assessments completed by each student, their demographic and identifying information, a variety of state and federal use codes, and students' raw and scaled scores that determine a student's pass/fail status. Every Virginia school district is provided with the finalized student data file during the summer, after the test administration window has closed and all adjustments (i.e. information reporting corrections, resolution of testing irregularities, coding error corrections, etc.) have been made. Virginia school districts use the data files for a variety of purposes. For example, the information contained within the data file can be used to calculate pass rates for individual schools by grade level, test, teacher, etc. Achievement of state accreditation and federal Adequate Yearly Progress (AYP) benchmarks can also be estimated utilizing these data.

After the submission and approval of a research project application through the Research Department of School District A, this researcher obtained student performance data files from the 2009, 2010, and 2011 SOL administrations. A request was made that all information that could potentially identify any student (i.e. names, identification numbers, birth dates, etc.) be removed from the data sets prior to being released. Additionally, all other information not directly pertaining to the current study was removed from the data set; these include state and federal use codes, accreditation adjustment indicators, etc. The modified data file provided to the researcher included only the following information about students: Student gender, disability status, race indicator, SES indicator, grade level test administered, total scaled score, and scales scores for RC1-RC5. Gender and disability status were included solely for the purpose of

controlling for these variables during the data analysis.

### *Data Cleaning Procedures*

When the data files were received, modifications occurred to ensure validity/reliability of the analysis. For example, the proposed study only pertains to Black and White students. Any data with racial indicators other than “3” (Black) and “5” (White) were deleted from the data set. Additionally, information corresponding to SOL assessments other than mathematics, such as reading, science, history, etc. were eliminated from the file. The data file also contained specific codes that are reported in the “total scaled score” and “RC scaled score” sections for each student. These codes are numbers falling in the 900s, outside of the scaled score ranges, and are used to denote special student circumstances (i.e. 991= student was absent from testing, 992= student previously passed test, etc.). All “scores” falling outside of the range of 0-600 for the total scaled score category, and 0-50 for the RC scaled score category, were deleted from the file. Finally, once the data set was pared to isolate information only relevant to mathematics assessment, it was necessary for the researcher to eliminate information related to high-school level mathematics achievement.

At End-of-Course (EOC) high-school level mathematics, reporting categories begin to deviate from the standard format used in Grades 3-8. For example, whereas RC1 measures “Number and Number Sense” for all mathematics SOL tests Grades 3-8, RC1 for Algebra I students measures “Expressions and Operations.” This variation continues for each high-school EOC mathematics course (Geometry RC1= Lines and Angles, Trigonometry RC1= Triangular and Circular Trigonometric Functions, etc.) making it impossible to synthesize mathematics achievement in Grades 3-8 with high-school level mathematics achievement. The raw data file,



however, does not differentiate RC Scaled Scores among the types of mathematics test administered. Therefore, all high-school level EOC mathematics testing data was eliminated from the data set. The current study only considers elementary (Grades 3-5) and middle school (Grades 6-8) level mathematics performance.

After the data file was cleaned and prepared for analysis, descriptive statistics were obtained from the data set to denote the number of mathematics achievement scores that were analyzed during each respective school year. The reader is referred to *Table 2* for descriptive statistics of the entire population.

### *Data Analysis*

To determine the presence of a statistically significant difference in overall mathematics achievement between Black and White students, Analysis of Covariance (ANCOVA) of the total test scaled score was conducted to identify the main effects of race on broad mathematics achievement. ANCOVA was also conducted on the total test scaled scores of socioeconomically disadvantaged and advantaged students to identify the main effect of socioeconomic status on broad mathematics achievement, and to determine statistical significance of any noted variance. Gender and student disability status were included as covariates in order to control for their influence on the main effects of the independent variables.

To determine statistically significant differences in strand-based mathematics achievement between Black and White students, and socioeconomically disadvantaged and advantaged students, Multivariate Analysis of Covariance (MANCOVA) was also conducted for the independent variables in each reporting category of the mathematics tests in Grades 3-8. Reporting categories for each grade level were analyzed in their own respect to accurately reflect

student performance on the specific domain corresponding to the content strand. For example, student mathematics achievement scores within the Computation and Estimation category (RC2) were only compared to other Computation and Estimation scores in each grade level. Gender and disability status were also controlled for in the strand-based analysis using MANCOVA.

To determine the presence of any interaction between race, socioeconomic status, and school level in mathematics achievement, 2x2x2 Factorial ANCOVA and MANCOVA were conducted for both overall and strand-based mathematics achievement scores. For efficiency and parsimony in the analysis of the data, results of the factorial analysis were already included in the ANCOVA and MANCOVA when conducted to answer the previous questions concerning overall and strand-based math achievement.

To identify practical implications for any significant differences revealed in the ANCOVA and MANCOVA for each grade level test, effect sizes (Partial  $\eta^2$ ) were also calculated and listed for all  $F$  ratios that are statistically significant. Effect size calculations are appropriate to use when investigators desire to know the magnitude of statistically significant differences (Mitchell & Jolley, 2010). Partial  $\eta^2$  calculations for each statically significant  $F$  ratio determine whether variances are relevant in a meaningful sense.

Table 2

*2009-2011 Sample Statistics by Category- Total Population*

	Test Administration Year					
	2009		2010		2011	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Gender						
Male	8,432	52	8,369	52	8,959	52
Female	7,845	48	7,808	48	8,317	48
Race						
Black	7,201	44	7,385	46	7,564	44
White	8,968	56	8,792	54	9,712	56
SPED Status						
Not SPED	14,396	89	14,337	89	14,925	86
SPED	1,791	11	1,840	11	2,351	14
Disadv. (SES) Status						
High-SES	11,319	70	10,463	65	10,662	62
Low-SES	4,868	30	5,714	35	6,614	38
School Level						
Elementary (Gr. 3-5)	8,596	53	8,779	54	9,564	55
Middle (Gr. 6-8)	7,591	47	7,398	46	7,712	45

*Delimitations*

While it is the intent of this research to produce results that will be generalizable to a much larger population, the current study contains delimitations that act to narrow the scope of the findings. It should be noted that only criterion-referenced achievement data from the Virginia Mathematics SOL Assessments are being used. These assessments align with the previously implemented 2001 Virginia mathematics curriculum and, while possibly reliable in determining mathematics achievement levels for students not exposed to this curriculum, should be considered most reliable for Virginia students from 2001-2011 only. The data analysis also solely applies to Black and White students in Grades 3-8 who took a mathematics SOL test during the years 2009, 2010, and 2011. Finally, students from different geographic regions of

Virginia were not represented in the data analysis; only data from students living in Central Virginia are included in the current study.

#### *VCU IRB*

The current study is a secondary data analysis, and therefore falls under Category 4 of IRB Exempt Review. After approval was obtained by the Dissertation Prospectus Committee, the researcher applied for and was granted authorization to proceed from the VCU IRB in accordance with University policy.

## Chapter 4

### Results

Two primary data analyses methods were conducted to answer all of the research questions. A 2x2x2 Factorial ANCOVA was utilized to obtain information about overall math achievement by race, socioeconomic status, and school level. A 2x2x2 Factorial MANCOVA was utilized to obtain information about strand-based math achievement by race, socioeconomic status, and school level. In both analyses, factorial design allowed this researcher to examine the interaction among all independent variables for both overall and strand-based math achievement. Univariate and Multivariate Analyses of Covariance (ANCOVA and MANCOVA) were appropriate methods to utilize for two primary reasons. Including gender and special education status as covariates allowed this researcher to control for a their influence on the main effect of the independent variables on the dependent measures. Finally, conducting one ANCOVA and one MANCOVA allowed this investigator to answer the research questions using a parsimonious analysis method that reduced error and increased efficiency. Results were extracted from the ANCOVA and MANCOVA and are reported in separate tables which apply to the research questions.

#### Descriptive Statistics

The analyses were conducted on a random sample of 10% of the total population (See *Table 1*) in an effort to control for the statistical significance that would be encountered with a large number of participants. *Table 3* displays the descriptive statistics of the sample used, including the *n* and percentages of the covariates. When compared to the percentages of the total

population for each independent variable and covariate, all sampled variable categories correspond to the makeup of the total population within at least one percentage point. There was an exception for students receiving special education services in 2011, which varied from the total population by two percentage points. However, it is not believed that this factor had any significant impact on the results of the analyses.

Table 3

*2009-2011 Sample Statistics by Category- 10% of Total Population*

	Test Administration Year					
	2009		2010		2011	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Gender						
Male	823	51	819	51	898	53
Female	776	49	788	49	793	47
Race						
Black	703	44	753	47	719	43
White	896	56	854	53	972	57
SPED Status						
Not SPED	1,433	90	1,416	88	1,485	88
SPED	166	10	191	12	206	12
Disadv. (SES) Status						
High-SES	1,133	71	1,048	65	1,062	63
Low-SES	466	29	559	35	629	37
School Level						
Elementary (Gr. 3-5)	855	53	861	54	947	56
Middle (Gr. 6-8)	744	47	746	46	744	44

## Statistical Analyses

### *Analysis of Covariance for Overall Math Achievement*

Tables 4-6 display the statistical results of ANCOVAs performed on the data in 2009, 2010, and 2011. The reader is referred to these tables for a summary of statistical significance, effect sizes, and interaction of variables for overall mathematics achievement. Detailed information concerning mean differences between subgroups and effect sizes is provided in the sections to follow.

Table 4

### *2009 Analysis of Covariance Statistical Results- Overall Math Achievement*

Subgroup	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>p</i>	$\eta^2$
Gender (Covariate)	1	674.87	674.87	.12	.727	.000
SPED (Covariate)	1	962,863.66	962,863.66	174.35	.000	.099
Race (R)	1	355,557.81	355,557.81	64.38	.000	.039
Disadv. Status (SES)	1	438,907.17	438,907.17	79.47	.000	.048
School Level (SL)	1	481,156.60	481,156.60	87.12	.000	.052
R x SL	1	34,628.06	34,628.06	6.27	.012	.004
SES x SL	1	430.74	430.74	.08	.780	.000
R x SES	1	90,076.55	90,076.55	16.31	.000	.010
R x SES x SL	1	345.10	345.10	.06	.803	.000
Error	1,589	8,775,527.56	5,522.67			
Total	1,599	382,449,459				

Table 5

*2010 Analysis of Covariance Statistical Results- Overall Math Achievement*

Subgroup	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>p</i>	$\eta^2$
Gender (Covariate)	1	1,219.20	1,219.20	.24	.624	.000
SPED (Covariate)	1	930,234.82	930,234.82	182.95	.000	.103
Race (R)	1	388,226.74	388,226.74	76.35	.000	.046
Disadv. Status (SES)	1	389,731.44	389,731.44	76.65	.000	.046
School Level (SL)	1	932,763.53	932,763.53	183.45	.000	.103
R x SL	1	34,971.79	34,971.79	6.88	.009	.004
SES x SL	1	1,228.97	1,228.97	.24	.623	.000
R x SES	1	78,993.34	78,993.34	15.54	.000	.010
R x SES x SL	1	364.99	364.99	.07	.789	.000
Error	1,597	8,120,172.78	5,084.64			
Total	1,607	398,661,203				

Table 6

*2011 Analysis of Covariance Statistical Results- Overall Math Achievement*

Subgroup	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>p</i>	$\eta^2$
Gender (Covariate)	1	2,874.31	2,874.31	.51	.474	.000
SPED (Covariate)	1	856,807.80	856,807.80	152.65	.000	.083
Race (R)	1	423,238.63	423,238.63	75.41	.000	.043
Disadv. Status (SES)	1	328,618.02	328,618.02	68.17	.000	.039
School Level (SL)	1	1,289,936.21	1,289,936.21	229.82	.000	.120
R x SL	1	20,100.51	20,100.51	3.58	.059	.002
SES x SL	1	10.47	10.47	.002	.966	.000
R x SES	1	97,055.78	97,055.78	17.29	.000	.010
R x SES x SL	1	9,594.14	9,594.14	1.71	.191	.001
Error	1,681	9,435,224.89	5,612.86			
Total	1,691	410,600,037				



### *Overall Math Achievement by Race and School Level*

Data analysis reveals that a statistically significant difference in overall mathematics achievement exists between Black and White students in all three years examined. In 2009, the overall mean score for Black students was 444.74, and White students obtained a mean score of 509.37. Black students in 2010 obtained a mean score of 457.48, and the mean score for White students was 519.32. In 2011, the mean score for Black students was 451.34, and White students obtained an overall mean score of 508.76. Each mean variance was highly significant ( $p = .000$ ).

Differences in the mean scores of Black and White students were also found to be significant in their relationship to school level in 2009 ( $p = .012$ ) and 2010 ( $p = .009$ ). In 2009, Black elementary school students obtained a mean overall score of 468.94, and the mean score for White elementary students was 523.73. In the same year, the overall mean for Black middle school students was 417.70, and White middle school students obtained a mean score of 492.51. Black elementary school students in 2010 obtained an overall mean score of 488.66, and White elementary school students scored 540.03. Black middle school students in the same year scored 423.81, and White middle school students obtained an overall mean score of 493.96. Interaction between race and school level in 2011 was not strong enough to be considered statistically significant. Mean differences in overall math achievement between Black and White students by school level are displayed in *Table 7*. A visual representation of mean comparisons between race and school level can be found in *Figure 7*.

Effect size was calculated to determine if there was any practical significance that corresponded with statistical significance of mean differences between Black and White students. The current analysis revealed very small effect sizes for statistically significant

differences in overall mathematics achievement. While each year examined revealed statistical significance between the mean differences by race, the effect sizes were calculated at .039 in 2009, 0.46 in 2010, and .043 in 2011. When factoring school level with race for significant overall math achievement mean differences, effect sizes were also found to be small. In 2009 and 2010, effect sizes were equivalent at .004, which are considered very small. This means that practical significance, or the degree to which the differences are realized in real world application, is limited.

Table 7

*2009-2011 Mean Differences- Overall Math Achievement by Race and School Level*

Student Race	School Year											
	2009				2010				2011			
	<u>Black Students</u>		<u>White Students</u>		<u>Black Students</u>		<u>White Students</u>		<u>Black Students</u>		<u>White Students</u>	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
School Level												
Elementary	468.94	74.93	523.73	77.52	488.66	79.25	540.03	63.36	485.42	77.53	532.03	67.85
Middle	417.70	89.56	492.51	79.71	423.81	82.69	493.96	84.10	412.06	89.16	476.87	90.10
<b>Total</b>	<b>444.74</b>	<b>86.00</b>	<b>509.37</b>	<b>80.12</b>	<b>457.48</b>	<b>87.13</b>	<b>519.32</b>	<b>76.87</b>	<b>451.34</b>	<b>90.78</b>	<b>508.76</b>	<b>82.60</b>

Table 8

*2009-2011 Mean Differences- Overall Math Achievement by Race and Socioeconomic Status*

Disadvantaged Status	School Year											
	2009				2010				2011			
	<u>Low SES</u>		<u>High SES</u>		<u>Low SES</u>		<u>High SES</u>		<u>Low SES</u>		<u>High SES</u>	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Race												
Black Students	436.19	81.99	453.97	89.34	450.53	87.30	467.06	86.11	445.39	91.12	460.56	89.65
White Students	448.17	89.69	517.15	75.28	473.19	83.90	527.08	72.86	463.33	89.48	519.94	76.86
<b>Total</b>	<b>438.79</b>	<b>83.77</b>	<b>498.30</b>	<b>84.78</b>	<b>455.51</b>	<b>87.00</b>	<b>508.92</b>	<b>81.86</b>	<b>450.87</b>	<b>90.92</b>	<b>504.18</b>	<b>84.58</b>

Figure 7

*2009-2011 Mean Comparisons- Overall Math Achievement by Race and School Level*

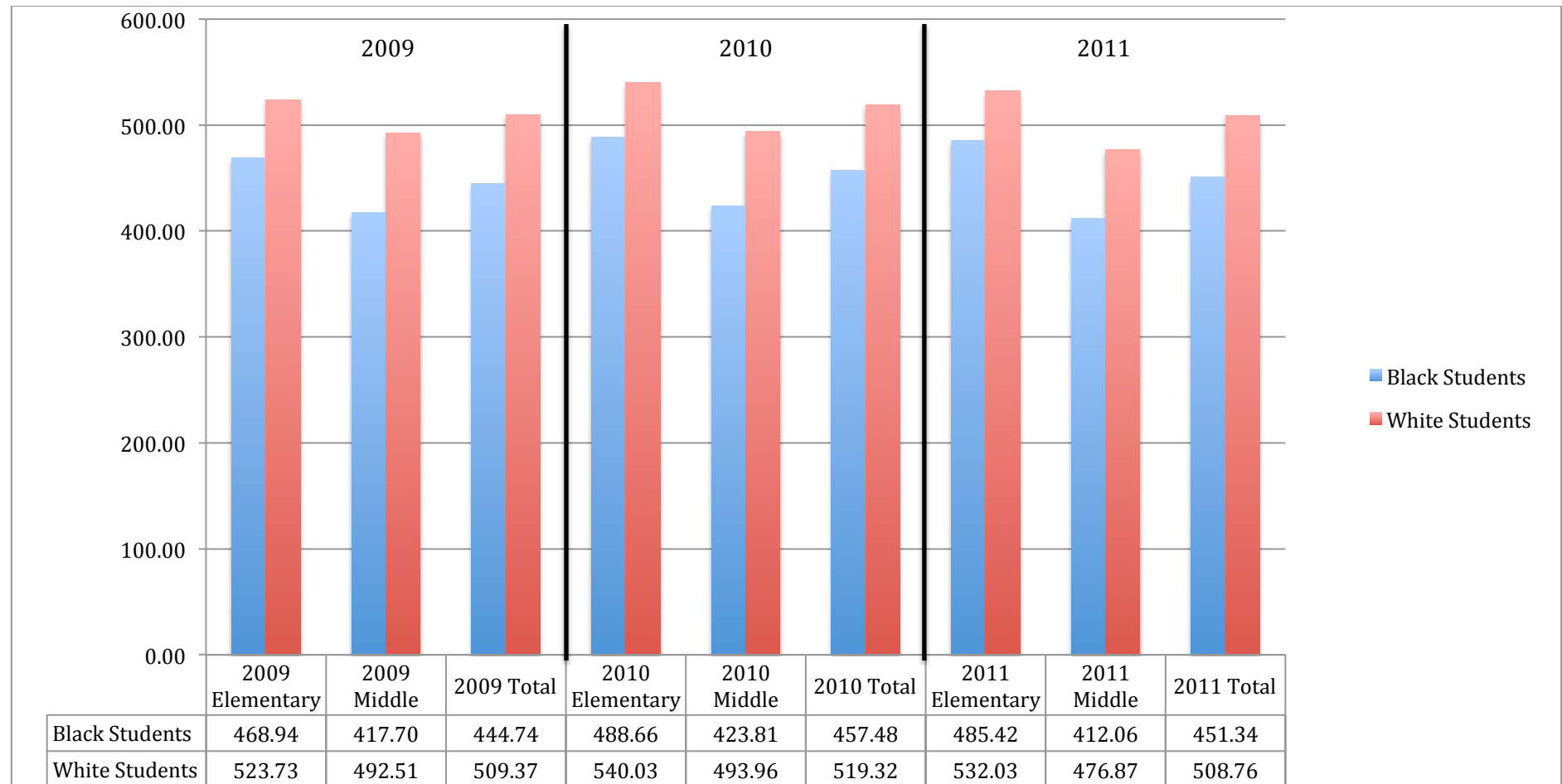
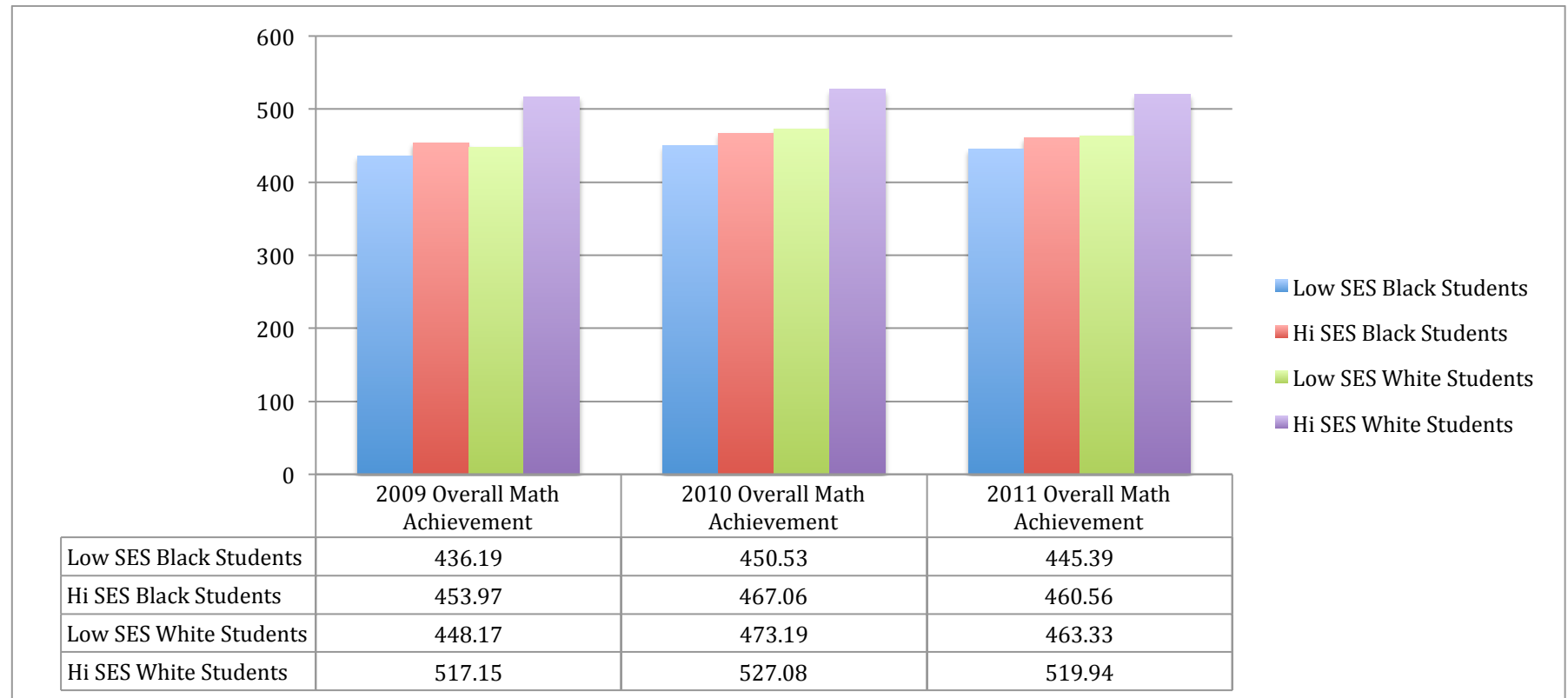


Figure 8

*2009-2011 Mean Comparisons- Overall Math Achievement by Race and Socioeconomic Status*



### *Overall Math Achievement by Race and Socioeconomic Status*

Significant differences in overall mean scores were revealed between socioeconomically disadvantaged and advantaged students. These differences occurred in each year of data analyzed. Additionally, when race was factored in, the interaction between socioeconomic status and race was significant ( $p = .000$ ) in each year. In 2009, the total mean for disadvantaged students was 438.79, and advantaged student obtained an overall mean score of 498.30. Disadvantaged students in 2010 obtained a total mean score of 455.51, and the mean score for advantaged students was 508.92. In 2011, the mean score for disadvantaged students was 450.87, and White students obtained an overall mean score of 504.18. Mean variances were highly significant ( $p = .000$ ) for each year. The reader is referred to *Table 8* for detailed results of mean differences in overall mathematics achievement by socioeconomic status and race. *Figure 8* contains a comparison of overall math achievement from 2009-2011 by race and socioeconomic status.

No significant differences were revealed when overall mean scores between disadvantaged and advantaged students were compared by elementary and middle school level in any of the years examined. Additionally, effect sizes corresponding to significant differences within the socioeconomic subgroup were considered very small. Partial  $\eta^2$  coefficients were calculated at .048 in 2009, .046 in 2010, and .039 in 2011. Similar to the effect size findings between Black and White, these data also indicate that meaningful significance of mean differences between socioeconomically disadvantaged and advantaged students is very limited.

### *Multivariate Analysis of Covariance for Strand-Based Math Achievement*

*Tables 9-11* display the statistical results of MANCOVAs performed on the data in 2009, 2010, and 2011. The reader is referred to these tables for a summary of statistical significance, effect sizes, and interaction of variables for mathematics achievement by specific content strand. Additionally, *Tables 12-14* display the correlations among the strand scores in each reporting category. Detailed information concerning mean differences between subgroups and effect sizes is provided in the sections to follow.

### *Strand-Based Math Achievement by Race and School Level*

When the mathematics content strand scaled scores of Black and White students were compared, differences in the means between the groups were found to be highly significant ( $p = .000$ ). This result occurred in each of the years analyzed, and was consistent with the finding regarding comparisons between race and overall mathematics achievement. Effect size calculations of the significant differences were also commensurate with the results of the overall achievement analysis. Practical significance coefficients were measured at their lowest in the Numbers and Number Sense [RC1] strand in 2009 ( $\eta^2 = .011$ ) and highest in 2011 in the Probability and Statistics strand ( $\eta^2 = .046$ ). All effect sizes are considered very small, and demonstrate limited practical significance.

When mean scores by race and reporting category were examined, Black students achieved the highest scores in the Numbers and Number Sense [RC1] category each year when performance was compared with all other content strands within their group.

Table 9

*2009 Multivariate Analysis of Covariance Statistical Results- Strand Based Math Achievement*

Subgroup	Content Strand [Reporting Category]														
	Numbers and Number Sense [RC1]			Computation and Estimation [RC2]			Measurement and Geometry [RC3]			Probability and Statistics [RC4]			Patterns, Functions, and Algebra [RC5]		
	<i>F</i>	<i>p</i>	$\eta^2$	<i>F</i>	<i>p</i>	$\eta^2$	<i>F</i>	<i>p</i>	$\eta^2$	<i>F</i>	<i>p</i>	$\eta^2$	<i>F</i>	<i>p</i>	$\eta^2$
Gender (CV)	.48	.487	.000	2.95	.086	.002	1.02	.312	.001	.87	.351	.001	1.27	.259	.001
SPED (CV)	78.27	.000	.047	66.29	.000	.040	112.01	.000	.066	129.35	.000	.075	163.05	.000	.093
Race (R)	17.40	.000	.011	44.68	.000	.027	48.16	.000	.029	43.19	.000	.026	39.29	.000	.024
Disadv. (SES)	48.86	.000	.030	33.14	.000	.020	39.73	.000	.024	42.50	.000	.026	39.17	.000	.024
School Lev (SL)	25.64	.000	.016	61.97	.000	.038	101.19	.000	.060	62.33	.000	.038	113.14	.000	.066
R x SL	.001	.977	.000	10.35	.001	.006	.32	.570	.000	8.38	.004	.005	.18	.675	.000
SES x SL	.65	.421	.000	.23	.630	.000	2.38	.123	.001	.53	.468	.000	.15	.698	.000
R x SES	9.32	.002	.006	3.58	.059	.002	11.17	.001	.007	10.83	.001	.007	10.39	.001	.006
R x SES x SL	.27	.605	.000	.35	.556	.000	1.02	.313	.001	.08	.772	.000	.18	.668	.000

Note: (CV) = Covariate



Table 10

*2010 Multivariate Analysis of Covariance Statistical Results- Strand Based Math Achievement*

Content Strand [Reporting Category]															
Subgroup	Numbers and Number Sense [RC1]			Computation and Estimation [RC2]			Measurement and Geometry [RC3]			Probability and Statistics [RC4]			Patterns, Functions, and Algebra [RC5]		
	<i>F</i>	<i>p</i>	$\eta^2$	<i>F</i>	<i>p</i>	$\eta^2$	<i>F</i>	<i>p</i>	$\eta^2$	<i>F</i>	<i>p</i>	$\eta^2$	<i>F</i>	<i>p</i>	$\eta^2$
Gender (CV)	.32	.571	.000	1.86	.173	.001	.28	.595	.000	.09	.770	.000	.00	.992	.000
SPED (CV)	79.88	.000	.048	73.09	.000	.044	128.13	.000	.074	98.74	.000	.058	129.65	.000	.075
Race (R)	21.50	.000	.013	33.51	.000	.021	63.81	.000	.038	54.99	.000	.033	36.55	.000	.022
Disadv. (SES)	44.44	.000	.027	44.07	.000	.027	42.00	.000	.026	46.51	.000	.028	36.81	.000	.023
School Lev (SL)	100.39	.000	.059	90.89	.000	.054	183.73	.000	.103	220.06	.000	.121	132.13	.000	.076
R x SL	.40	.527	.000	11.23	.001	.007	.41	.524	.000	8.30	.004	.005	.54	.461	.000
SES x SL	2.92	.088	.002	.02	.898	.000	.02	.880	.000	1.74	.187	.001	.22	.638	.000
R x SES	11.17	.001	.007	6.90	.009	.004	15.95	.000	.010	7.32	.007	.005	4.79	.029	.003
R x SES x SL	1.26	.263	.001	.18	.674	.000	1.16	.282	.001	.85	.357	.001	.77	.380	.000

Note: (CV) = Covariate

Table 11

*2011 Multivariate Analysis of Covariance Statistical Results- Strand Based Math Achievement*

Subgroup	Content Strand [Reporting Category]														
	Numbers and Number Sense			Computation and Estimation			Measurement and Geometry			Probability and Statistics			Patterns, Functions, and		
	[RC1]			[RC2]			[RC3]			[RC4]			Algebra [RC5]		
	<i>F</i>	<i>p</i>	$\eta^2$	<i>F</i>	<i>p</i>	$\eta^2$	<i>F</i>	<i>p</i>	$\eta^2$	<i>F</i>	<i>p</i>	$\eta^2$	<i>F</i>	<i>p</i>	$\eta^2$
Gender (CV)	.43	.514	.000	.05	.818	.000	1.24	.265	.001	1.64	.201	.001	.06	.805	.000
SPED (CV)	83.22	.000	.047	75.29	.000	.043	98.85	.000	.056	79.52	.000	.045	81.69	.000	.046
Race (R)	25.57	.000	.015	34.65	.000	.020	58.46	.000	.034	80.18	.000	.046	27.89	.000	.016
Disadv. (SES)	27.43	.000	.016	28.64	.000	.017	42.50	.000	.025	43.78	.000	.025	55.65	.000	.032
School Lev (SL)	141.94	.000	.078	92.40	.000	.052	240.11	.000	.125	238.91	.000	.124	171.56	.000	.093
R x SL	.31	.579	.000	1.41	.235	.001	.05	.822	.000	7.05	.008	.004	.94	.332	.001
SES x SL	.40	.527	.000	.30	.585	.000	1.01	.315	.001	.02	.888	.000	2.72	.099	.002
R x SES	10.72	.001	.006	8.73	.003	.005	7.15	.008	.004	9.39	.002	.006	12.03	.001	.007
R x SES x SL	.16	.687	.000	1.90	.169	.001	1.82	.177	.001	.09	.766	.000	2.79	.095	.002

Note: (CV) = Covariate

Table 12

*2009 Correlations for Math Content Strand Scores*

Content Strand [Reporting Category]	1	2	3	4	5
1. Numbers and Number Sense [RC1]	--	.57**	.59**	.55**	.55**
2. Computation and Estimation [RC2]	.57**	--	.58**	.55**	.56**
3. Measurement and Geometry [RC3]	.59**	.58**	--	.57**	.61**
4. Probability and Statistics [RC4]	.55**	.55**	.57**	--	.59**
5. Patterns, Functions, and Algebra [RC5]	.55**	.56**	.61**	.59**	--

\*\* $p < .01$ 

Table 13

*2010 Correlations for Math Content Strand Scores*

Content Strand [Reporting Category]	1	2	3	4	5
1. Numbers and Number Sense [RC1]	--	.54**	.56**	.52**	.53**
2. Computation and Estimation [RC2]	.54**	--	.56**	.53**	.56**
3. Measurement and Geometry [RC3]	.56**	.56**	--	.58**	.63**
4. Probability and Statistics [RC4]	.52**	.53**	.58**	--	.55**
5. Patterns, Functions, and Algebra [RC5]	.53**	.56**	.63**	.55**	--

\*\* $p < .01$ 

Table 14

*2011 Correlations for Math Content Strand Scores*

Content Strand [Reporting Category]	1	2	3	4	5
1. Numbers and Number Sense [RC1]	--	.59**	.60**	.54**	.57**
2. Computation and Estimation [RC2]	.59**	--	.58**	.54**	.58**
3. Measurement and Geometry [RC3]	.60**	.58**	--	.61**	.63**
4. Probability and Statistics [RC4]	.54**	.54**	.61**	--	.59**
5. Patterns, Functions, and Algebra [RC5]	.57**	.58**	.63**	.59**	--

\*\* $p < .01$

Similarly, White students as a subgroup performed the highest in the Probability and Statistics [RC4] content strand; this also occurred consistently for each testing year. These data suggest that Black students were able to complete mathematics problems that involved simple mathematical concepts with higher success than problems in other more challenging domains. Conversely, White students as a group scored lower on tasks that involved less complex math tasks, and achieved the highest scores in a more conceptually challenging category.

The lowest scores for each group were consistent in 2009 and 2011, and varied slightly in 2010. In 2009, the Computation and Estimation [RC2] strand was the most difficult for both Black students ( $M = 34.28$ ,  $SD = 10.03$ ) and White students ( $M = 39.96$ ,  $SD = 9.09$ ). In 2010, Black students scored the lowest in the Measurement and Geometry [RC3] strand ( $M = 35.07$ ,  $SD = 8.61$ ), and White students had the most difficulty with the Patterns, Functions, and Algebra [RC5] strand ( $M = 40.71$ ,  $SD = 8.65$ ). Scores for White students in RC3 in 2010 were only *slightly* higher ( $M = 40.84$ ,  $SD = 8.17$ ) than RC4 for the same year. This detail should be observed because the data from 2011 reveal that both groups of students continued to have the most difficulty in the Measurement and Geometry content strand. Black students ( $M = 34.65$ ,  $SD = 8.76$ ) and White students ( $M = 39.67$ ,  $SD = 8.37$ ) scored the lowest within their own respective groups in this domain of mathematics knowledge. These data suggest that all students, regardless of race, had a tendency to score the lowest in the same conceptual categories.

The current data analysis also produced information concerning the relationship between strand-based math performance for Black and White students when school level is factored in as a variable. In 2009, significant interaction between student race and

school level were identified in the Computation and Estimation [RC2] strand ( $p = .001$ ) and in the Probability and Statistics strand ( $p = .004$ ). The data analysis for 2010 revealed significant differences for the same reporting categories, and produced identical  $\alpha$  levels. In 2011, significant interaction was revealed in only the Probability and Statistics strand ( $p = .008$ ). When the effect sizes of the significant  $F$  ratios were examined,  $\eta^2$  figures ranged from .004 at the smallest to .007 at the largest. These data indicate that there is virtually no practical significance of the interaction identified among Black and White students at elementary and middle school levels in the content strands.

In the Computation and Estimation [RC2] strand, White elementary school students scored the lowest within their subgroup in 2009 ( $M = 41.18$ ,  $SD = 8.62$ ) and 2010 ( $M = 42.81$ ,  $SD = 7.84$ ). This was also true for Black middle school students ( $M = 31.11$ ,  $SD = 10.75$ ), albeit only in 2009. In the Probability and Statistics [RC4] strand, Black elementary school students scored the highest within their subgroup in 2009 and 2010, while the same strand was weakest for Black middle school students in 2011 ( $M = 30.42$ ,  $SD = 8.72$ ). White elementary school students performed the highest in Probability and Statistics [RC4] in 2010 and 2011, and White middle school students obtained the highest scores in 2009 and 2010 in the same category. Mean differences in strand-based mathematics achievement between Black and White students by school level are displayed in *Tables 15-17*.

Table 15

*2009 Mean Differences- Strand Based Math Achievement by Race and School Level*

	Content Strand [Reporting Category]									
	Numbers and Number Sense [RC1]		Computation and Estimation [RC2]		Measurement and Geometry [RC3]		Probability and Statistics [RC4]		Patterns, Functions, and Algebra [RC5]	
Race x Sch. Lev.	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Black	36.52	8.99	37.12	8.39	36.83	8.45	37.54	9.87	37.11	9.62
Elem.										
Black	33.98	10.93	31.11	10.75	31.81	8.27	31.87	9.13	31.86	7.82
Middle										
<b>Total</b>	<b>35.32</b>	<b>10.03</b>	<b>34.28</b>	<b>10.03</b>	<b>34.46</b>	<b>8.73</b>	<b>34.86</b>	<b>9.94</b>	<b>34.63</b>	<b>9.19</b>
<b>Black</b>										
White	41.93	9.13	41.18	8.62	42.15	8.28	42.51	9.53	42.64	9.15
Elem										
White	38.85	10.24	38.53	9.43	37.64	8.08	39.34	9.02	37.15	7.39
Middle										
<b>Total</b>	<b>40.52</b>	<b>9.77</b>	<b>39.96</b>	<b>9.09</b>	<b>40.08</b>	<b>8.49</b>	<b>41.05</b>	<b>9.43</b>	<b>40.11</b>	<b>8.82</b>
<b>White</b>										

Table 16

*2010 Mean Differences- Strand Based Math Achievement by Race and School Level*

	Content Strand [Reporting Category]									
	Numbers and Number Sense [RC1]		Computation and Estimation [RC2]		Measurement and Geometry [RC3]		Probability and Statistics [RC4]		Patterns, Functions, and Algebra [RC5]	
Race x Sch. Lev.	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Black	38.88	9.11	39.12	9.16	37.94	8.40	40.50	9.86	38.43	9.95
Elem.										
Black	34.22	10.07	32.71	9.71	31.97	7.73	31.99	8.31	32.80	8.43
Middle										
<b>Total</b>	<b>36.64</b>	<b>9.86</b>	<b>36.04</b>	<b>9.95</b>	<b>35.07</b>	<b>8.61</b>	<b>36.41</b>	<b>10.09</b>	<b>35.72</b>	<b>9.66</b>
<b>Black</b>										
White	43.66	7.89	42.81	7.84	43.40	7.11	44.69	7.81	43.41	8.08
Elem										
White	38.85	10.18	39.26	9.66	37.70	8.30	39.33	8.77	37.40	8.17
Middle										
<b>Total</b>	<b>41.50</b>	<b>9.30</b>	<b>41.22</b>	<b>8.88</b>	<b>40.84</b>	<b>8.17</b>	<b>42.28</b>	<b>8.67</b>	<b>40.71</b>	<b>8.65</b>
<b>White</b>										

Table 17

*2011 Mean Differences- Strand Based Math Achievement by Race and School Level*

Race x Sch. Lev.	Content Strand [Reporting Category]									
	Numbers and Number Sense [RC1]		Computation and Estimation [RC2]		Measurement and Geometry [RC3]		Probability and Statistics [RC4]		Patterns, Functions, and Algebra [RC5]	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Black	39.21	9.28	38.58	8.96	37.74	7.85	39.34	9.90	38.46	9.73
Elem.										
Black	32.50	10.05	32.86	10.33	31.09	8.40	30.42	8.72	31.95	8.68
Middle										
<b>Total</b>	<b>36.09</b>	<b>10.20</b>	<b>35.92</b>	<b>10.03</b>	<b>34.65</b>	<b>8.76</b>	<b>35.30</b>	<b>10.37</b>	<b>35.43</b>	<b>9.80</b>
<b>Black</b>										
White	42.86	8.22	42.26	8.22	42.45	7.18	44.07	8.14	42.63	8.46
Elem										
White	37.12	10.62	38.32	10.60	35.85	8.40	37.75	9.24	36.66	8.47
Middle										
<b>Total</b>	<b>40.44</b>	<b>9.73</b>	<b>40.60</b>	<b>9.50</b>	<b>39.67</b>	<b>8.37</b>	<b>41.40</b>	<b>9.17</b>	<b>40.11</b>	<b>9.96</b>
<b>White</b>										

### *Strand-Based Math Achievement by Socioeconomic Status and School Level*

When the mathematics content strand scaled scores of socioeconomically disadvantaged and advantaged students were compared, the statistical differences in the means between the groups were found to be highly significant ( $p = .000$ ). This result mirrors the finding regarding comparisons between the two subgroups on overall math achievement for each of the three years as well. Practical significance analyses of the significant differences were commensurate with the results of the overall achievement analysis. Effect size coefficients were measured at their lowest in the Numbers and Number Sense [RC1] category ( $\eta^2 = .016$ ), and their highest in the Patterns, Functions, and Algebra [RC5] ( $\eta^2 = .032$ ) both in 2011. These effect sizes indicate very limited practical significance of the differences in mean reporting category scores between socioeconomically disadvantaged and advantaged students.

Examination of mean scores by socioeconomic subgroup in the content strands analyzed revealed information concerning disadvantaged and advantaged students and the low-scoring category for each year. In 2009, both subgroups performed the lowest within their own population in the Computation and Estimation [RC2] strand. The Measurement and Geometry [RC3] strand was the lowest scoring area for both subgroups in 2010 and 2011. These data suggest that areas of the mathematics assessment that are most difficult for one socioeconomic subgroup were similarly challenging for the other subgroup, regardless of the significant differences in their mean scores across each strand. Data concerning the high-scoring categories of each subgroup were inconsistent, and only similar in the Probability and Statistics [RC4] strand in 2010. Additionally, no pattern was established regarding the tendency for one subgroup to score high in a



particular category across each year.

When school level was factored with mean strand scores variances between socioeconomically disadvantaged and advantaged students, no significant differences were identified. This indicates that there is little to no main effect produced by elementary or middle school level when considering the strand-based math scores of disadvantaged and advantaged students. *Tables 18-20* display the results of strand-based math scores by socioeconomic subgroup and school level.

Table 18

*2009 Mean Differences- Strand Based Math Achievement by Socioeconomic Status and School Level*

	Content Strand [Reporting Category]									
	Numbers and Number Sense [RC1]		Computation and Estimation [RC2]		Measurement and Geometry [RC3]		Probability and Statistics [RC4]		Patterns, Functions, and Algebra [RC5]	
Disad. x Sch. Lev.	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Low SES	35.17	9.19	36.42	8.64	36.82	8.87	36.46	10.31	36.49	10.20
Elem										
Low SES	33.32	10.48	30.92	10.85	31.05	7.76	32.03	8.51	31.61	7.74
Middle										
<b>Total</b>	<b>34.35</b>	<b>9.82</b>	<b>33.98</b>	<b>10.05</b>	<b>34.26</b>	<b>8.86</b>	<b>34.49</b>	<b>9.79</b>	<b>34.32</b>	<b>9.49</b>
<b>Low SES</b>										
High SES	41.50	8.91	40.72	8.48	41.16	8.38	42.04	9.36	41.87	9.08
Elem										
High SES	37.97	10.68	36.88	10.16	36.58	8.50	37.54	9.83	36.01	7.80
Middle										
<b>Total</b>	<b>39.83</b>	<b>9.94</b>	<b>38.90</b>	<b>9.50</b>	<b>38.99</b>	<b>8.74</b>	<b>39.91</b>	<b>9.84</b>	<b>39.09</b>	<b>8.98</b>
<b>High SES</b>										

Table 19

*2010 Mean Differences- Strand Based Math Achievement by Socioeconomic Status and School Level*

	Content Strand [Reporting Category]									
	Numbers and Number Sense [RC1]		Computation and Estimation [RC2]		Measurement and Geometry [RC3]		Probability and Statistics [RC4]		Patterns, Functions, and Algebra [RC5]	
Disad. x Sch. Lev.	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Low SES	38.64	9.21	38.27	9.29	37.69	8.46	40.05	10.03	37.97	9.96
Elem										
Low SES	32.96	10.07	32.36	10.52	31.92	7.05	31.50	8.39	32.23	8.06
Middle										
<b>Total</b>	<b>36.21</b>	<b>9.98</b>	<b>35.74</b>	<b>10.25</b>	<b>35.22</b>	<b>8.38</b>	<b>36.40</b>	<b>10.27</b>	<b>35.51</b>	<b>9.62</b>
<b>Low SES</b>										
High SES	43.18	8.08	42.83	7.78	42.82	7.38	44.40	7.98	43.03	8.35
Elem										
High SES	38.32	10.09	37.84	9.60	36.34	8.79	37.78	9.04	36.56	8.52
Middle										
<b>Total</b>	<b>40.83</b>	<b>9.42</b>	<b>40.42</b>	<b>9.05</b>	<b>39.69</b>	<b>8.72</b>	<b>41.20</b>	<b>9.13</b>	<b>39.90</b>	<b>9.03</b>
<b>High SES</b>										

Table 20

*2011 Mean Differences- Strand Based Math Achievement by Socioeconomic Status and School Level*

	Content Strand [Reporting Category]									
	Numbers and Number Sense [RC1]		Computation and Estimation [RC2]		Measurement and Geometry [RC3]		Probability and Statistics [RC4]		Patterns, Functions, and Algebra [RC5]	
Disad. x Sch. Lev.	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Low SES	39.03	9.45	38.37	9.12	37.47	8.02	39.11	9.99	37.49	9.61
Elem										
Low SES	32.15	10.19	32.79	10.41	31.16	8.33	30.78	9.30	31.81	8.64
Middle										
<b>Total</b>	<b>36.03</b>	<b>10.35</b>	<b>35.94</b>	<b>10.08</b>	<b>34.72</b>	<b>8.73</b>	<b>35.48</b>	<b>10.53</b>	<b>35.02</b>	<b>9.62</b>
<b>Low SES</b>										
High SES	42.79	8.15	42.20	8.14	42.37	7.07	43.97	8.15	42.99	8.34
Elem										
High SES	36.74	10.50	37.67	10.66	35.20	8.60	36.60	9.31	36.14	8.63
Middle										
<b>Total</b>	<b>40.11</b>	<b>9.74</b>	<b>40.20</b>	<b>9.61</b>	<b>39.20</b>	<b>8.56</b>	<b>40.71</b>	<b>9.42</b>	<b>39.96</b>	<b>9.12</b>
<b>High SES</b>										

### *Interaction Among Race, Socioeconomic Status, and School Level*

Analysis results in previous sections of this chapter identified interaction, or absence of interaction, between race and school level, and socioeconomic status and school level. However, the current study also seeks to detect and describe any interaction present between race and socioeconomic status in overall and strand-based mathematics achievement scores. Interaction among all three independent variables (race, socioeconomic status, and school level) was also tested for.

Factorial analysis conducted on race and socioeconomic status as fixed factors indicated a highly significant ( $p = .000$ ) interaction between the two variables. This finding was repeated for each year of testing data examined in both overall and strand-based mathematics achievement.

When overall math achievement was considered as the dependent variable, socioeconomically disadvantaged White students consistently performed higher than socioeconomically disadvantaged Black students. The same was true for socioeconomically advantaged White students and Black students. It should be noted that the differences in the mean between advantaged Black and White students were more disproportionate than mean differences between disadvantaged Black and White students. For example, in 2009, the mean difference between advantaged Black and White students was 63.18 points, as compared to 11.98 points for disadvantaged Black and White students. These disparities were similar in 2010 (60.02 vs. 22.66) and 2011 (59.38 vs. 17.94) respectively. Additionally, the differences in overall achievement scores between advantaged and disadvantaged student scores among the Black student subgroup were more narrow than those differences for White students. The mean difference between

Black advantaged and disadvantaged students was calculated at 17.78 in 2009, 16.53 in 2010, and 15.17 in 2011. For White students, the mean difference between advantaged and disadvantaged students within their subgroup was 68.98 in 2009, 53.89 in 2010, and 56.61 in 2011. This indicates that both disadvantaged and advantaged Black students tended to score more similarly to each other than disadvantaged and advantaged White students in overall math achievement. The mean scores for overall mathematics achievement by race and socioeconomic status can be found in *Table 21*.

The current data analysis revealed no practical significance for the interaction between race and socioeconomic status as independent variables for overall mathematics achievement. The effect size coefficient was measured to be the same ( $\eta^2 = .010$ ) for all three years of data analyzed.

When race, socioeconomic status, and school level were analyzed through 2x2x2 factorial analysis to identify any interaction for overall mathematics achievement among the three independent variables, no significant interaction was detected. It should be noted that there was relative variability between the 2011  $p$  value and the 2009 and 2010  $p$  values calculated. The  $\alpha$  levels in 2009 ( $p = .803$ ) and 2010 ( $p = .789$ ) were more similar to each other than in 2011 ( $p = .191$ ). Nevertheless, statistical significance was not established for interaction among race, socioeconomic status, and school level as fixed factors.

Table 21

*2009-2011 Mean Differences- Overall Math Achievement by Race, Socioeconomic Status, and School Level*

School Level	School Year											
	2009				2010				2011			
	<u>Elementary</u>		<u>Middle</u>		<u>Elementary</u>		<u>Middle</u>		<u>Elementary</u>		<u>Middle</u>	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Student Race x Disadv.												
Low SES Black	458.73	72.53	406.34	84.46	479.18	79.16	411.28	82.71	475.85	79.26	405.05	90.30
High SES Black	481.96	76.14	427.90	92.97	505.85	76.74	436.76	80.88	502.93	71.26	421.10	87.15
<b>Total Black</b>	<b>468.94</b>	<b>74.93</b>	<b>417.70</b>	<b>89.56</b>	<b>488.66</b>	<b>79.25</b>	<b>423.81</b>	<b>82.69</b>	<b>485.42</b>	<b>77.53</b>	<b>412.06</b>	<b>89.16</b>
Low SES White	462.39	101.76	433.66	73.66	496.71	78.70	444.11	81.60	493.53	75.68	426.10	91.52
High SES White	530.95	70.88	500.64	77.14	547.36	57.34	502.30	81.71	540.89	62.68	490.34	84.90
<b>Total White</b>	<b>523.73</b>	<b>77.52</b>	<b>492.51</b>	<b>79.71</b>	<b>540.03</b>	<b>63.36</b>	<b>493.96</b>	<b>84.10</b>	<b>532.03</b>	<b>67.85</b>	<b>476.87</b>	<b>90.10</b>

When strand-based scores were considered as dependent variables, interaction between race and socioeconomic status was significant among the content strands, with  $\alpha$  levels ranging from .029 - .000 in various categories. One exception was noted in 2009 for the Computation and Estimation [RC2] strand ( $p = .059$ ). Further analysis of mean strand-based scores revealed patterns among White and Black students in scoring the highest or lowest in specific categories for their subgroup. For example, Black disadvantaged students achieved the highest scores in the Numbers and Number Sense [RC1] strand relative to other categories in all three years. The same pattern was present for Black advantaged students in 2009 and 2010; in 2011, scores between the Numbers and Number Sense strand ( $M = 36.58$ ,  $SD = 9.69$ ) and the Computation and Estimation strand ( $M = 36.59$ ,  $SD = 10.05$ ) varied by only .01 points. White advantaged students scored the highest in the Probability and Statistics [RC4] category in all three years. Similarly, White disadvantaged students scored the highest in the same content strand in 2010 and 2011. A pattern was also established regarding tendencies to score the lowest in one category. Black advantaged students scored the lowest relative to other content strands in the Measurement and Geometry [RC3] category for all three years of data examined. Black disadvantaged students had similar results scoring the lowest in the same category in 2010 ( $M = 34.77$ ,  $SD = 8.29$ ) and 2011 ( $M = 34.09$ ,  $SD = 8.65$ ). No clear pattern was established for low scoring tendencies among White advantaged or White disadvantaged students. *Tables 22-24* display mean strand-based scores by race and socioeconomic status.

Although statistical significance in the interaction between race and socioeconomic status was established for strand-based math achievement in almost all

categories, the current analysis revealed no practical significance for this interaction.

Effect size coefficients ranged from  $\eta^2 = .003$  at the smallest to  $\eta^2 = .010$  at the largest.

When factorial analysis was conducted to identify any interaction among race, socioeconomic status, and school level and strand-based math scores, no significant interaction was detected. This finding is consistent with the results of the factorial analysis among the three independent variables and overall mathematics achievement.



Table 22

*2009 Mean Differences- Strand Based Math Achievement by Race and Socioeconomic Status*

Student Race												
Student SES	Black Students						White Students					
	Low SES		High SES		Total		Low SES		High SES		Total	
Content Strand [Reporting Category]	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Numbers and Number Sense [RC1]	34.30	9.64	36.43	10.33	35.32	10.03	34.54	10.48	41.27	9.42	40.52	9.77
Computation and Estimation [RC2]	33.52	10.07	35.11	9.93	34.28	10.03	35.64	9.87	40.51	8.84	39.96	9.09
Measurement and Geometry [RC3]	34.02	8.89	34.94	8.54	34.46	8.72	35.12	8.77	40.71	8.25	40.08	8.49
Probability and Statistics [RC4]	34.25	9.77	35.52	10.09	34.86	9.94	35.39	9.88	41.77	9.12	41.05	9.43
Patterns, Functions, and Algebra [RC5]	34.14	9.34	35.16	9.01	34.63	9.19	34.99	10.04	40.76	8.44	40.11	8.82

Table 23

*2010 Mean Differences- Strand Based Math Achievement by Race and Socioeconomic Status*

Student Race												
Student SES	Black Students						White Students					
	Low SES		High SES		Total		Low SES		High SES		Total	
Content Strand [Reporting Category]	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Numbers and Number Sense [RC1]	35.99	9.84	37.54	9.82	36.64	9.86	37.01	10.48	42.45	8.87	41.50	9.30
Computation and Estimation [RC2]	35.37	10.31	36.96	9.36	36.04	9.95	37.06	9.95	41.92	8.49	41.22	8.88
Measurement and Geometry [RC3]	34.77	8.29	35.48	9.03	35.07	8.61	36.85	8.54	41.51	7.92	40.84	8.17
Probability and Statistics [RC4]	35.86	10.23	37.16	9.85	36.41	10.09	38.30	10.22	42.95	8.20	42.28	8.67
Patterns, Functions, and Algebra [RC5]	35.04	9.74	36.66	9.50	35.72	9.66	37.18	9.03	41.30	8.45	40.71	8.65

Table 24

*2011 Mean Differences- Strand Based Math Achievement by Race and Socioeconomic Status*

Student Race												
Student SES	Black Students						White Students					
	<u>Low SES</u>		<u>High SES</u>		<u>Total</u>		<u>Low SES</u>		<u>High SES</u>		<u>Total</u>	
Content Strand [Reporting Category]	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Numbers and Number Sense [RC1]	35.78	10.52	36.58	9.69	36.09	10.20	36.60	9.97	41.39	9.44	40.44	9.73
Computation and Estimation [RC2]	35.49	10.01	36.59	10.05	35.92	10.03	36.95	10.21	41.50	9.10	40.60	9.50
Measurement and Geometry [RC3]	34.09	8.65	35.51	8.86	34.65	8.76	36.17	8.76	40.53	8.05	39.67	8.37
Probability and Statistics [RC4]	34.69	10.60	35.98	9.97	35.20	10.37	37.28	10.18	42.42	8.61	41.40	9.17
Patterns, Functions, and Algebra [RC5]	34.76	9.80	36.47	9.73	35.43	9.80	35.60	9.17	41.22	8.55	40.11	8.96

### *Gender and Special Education Status as Covariates*

Gender and student special education status were included in the current analysis as covariates to control for any influence on the independent variables. While the main effects of the covariates were not tested, the analysis did produce descriptive information concerning the significant differences in overall and strand based scores between males and females, and students receiving special education services and those without IEPs.

In overall mathematics achievement, no significance was revealed for gender as a variable for any of the years examined. Special education status was highly significant ( $p = .000$ ) for each year; however, effect size coefficients were small and did not reveal practical significance for the  $\alpha$  levels. The same pattern was observed when the significance of gender and special education status were considered for strand-based math achievement. Special education status was highly significant in all math content strands ( $p = .000$ ) for each year of data analyzed. Similar to overall math achievement, a range of very small effect sizes ( $\eta^2 = .040 - .093$ ) were noted, indicating limited practical significance. Mean differences in strand scores by gender were not found to be significant, which is consistent with the finding for overall math achievement.

## **Chapter 5**

### **Discussion**

#### **Summary of Results**

The results of the current study produced noteworthy findings in key areas of interest concerning mathematics achievement gap analysis. Foremost among these findings was the confirmation of the hypotheses regarding overall math achievement between Black and White students, and socioeconomically disadvantaged and advantaged students, as independent variables. The data analysis indicates that a statistically significant difference between the two levels of both subgroups does exist, as documented in the literature (NCES, 2011). Significant differences were also identified between Black and White students at elementary and middle school levels, indicating that race and school level interact as independent variables. Additionally, as cited in Braun, Wang, Jenkins, and Weinbaum (2006), interaction between student race and socioeconomic status was confirmed for overall math achievement. However, the current study did not produce data that indicated a significant interaction between socioeconomic status and school level, which does not confirm the hypothesis for overall mathematics achievement when the two subgroups are considered together.

The data analysis contradicts an important element of the research hypotheses concerning overall mathematics achievement. It was anticipated that statistically significant findings would also be paired with moderate to large effect sizes, thereby demonstrating practical significance. However, this was not the case; the current study yielded only very small effect sizes for statistically significant mean differences.

When considering strand-based mathematics achievement, the findings were similar to

those discovered in the overall math achievement analysis. Statistically significant differences were identified in all reporting categories between Black and White students; the same significant differences were found for socioeconomically disadvantaged students and advantaged students. Additionally, interaction was identified between socioeconomic status and race, as well as race and school level. The data analysis revealed small effect size coefficients, implying that practical significance of differences in strand-based math achievement is limited. However, other information revealed by the detailed strand analysis is noteworthy for patterns and tendencies of groups to score similarly from year to year.

Perhaps one of the more interesting findings of the study was the interaction between race and school level when strand-based math achievement is considered. The Computation and Estimation [RC2] and Probability and Statistics [RC4] strands consistently revealed significant differences by race and school level, with the exception of RC2 in 2011 ( $p = .235$ ). There was a strong tendency for elementary students to score highly in the Probability and Statistics [RC4] strand, as both Black and White students scored group highs in this category in 2010 and 2011; in 2009, White elementary students scored slightly higher in the Patterns, Functions, and Algebra [RC5] category. White middle school students scored highly in Probability and Statistics as well in 2009 and 2010. Both Black and White middle school students scored group highs in the Computation and Estimation [RC2] strand in 2011. Conversely, white elementary students scored low in the Computation and Estimation [RC2] strand each year. It is difficult to determine whether these findings are consistent with Lubienski & Crockett's (2007) analysis of 2003 NAEP data, which revealed that 4<sup>th</sup> and 8<sup>th</sup> grade Black and White students displayed the largest disparities in the "Measurement" strand. The content strands utilized by NAEP do not exactly mirror the content strands in the Virginia mathematics curriculum, which may or may not

contain test questions that overlap in conceptual domains. Furthermore, it is possible that the interaction revealed between race and school level reflected tendencies for certain subgroups to score more similarly than disproportionately in these two categories.

When race and socioeconomic status were examined with respect to strand-based math achievement, a few notable patterns emerged. There was a strong tendency for both low-SES and high-SES Black students to score highly in the Numbers and Number Sense [RC1] category. Low-SES Black students scored the highest in this strand for all three years, and high-SES black students achieved high scores in two of the three years. This is consistent with research that suggests recent mathematical gains made by Black students could be contributed to increased performance with basic and conceptually easier skills (Lubienski & Crockett, 2007). Black students also had the most difficulty with the math problems involving Measurement and Geometry [RC3], regardless of socioeconomic status; this finding is also consistent with Lubienski & Crockett (2007). This was the lowest scoring strand among low-SES and high-SES Black students, with the exception of high-SES Black students in 2009. White students tended to score the highest in the Probability and Statistics [RC4] strand, with the exception of low-SES White students in 2009.

Another noteworthy aspect of the findings concerns the degree of difference in the means between low-SES Black and White students, and high-SES Black and White students. While there are differences in mean scores by race and SES, low-SES Black students tended to score similarly to low-SES White students. In contrast, high-SES Black students scored approximately 5 points lower on average than high-SES white students in every category. The relatively narrow degree of difference can also be seen when comparing low and high-SES Black students with each other; differences in mean scores are not substantial. However, low and high-SES White

students do have a wider score spread, indicating that high-SES white students score consistently higher than the other subgroups.

Given the documented achievement gap between students by race and socioeconomic status, including information revealed in fine-grained data analysis by content strand, it is important to consider the implications for instructional and remediating practices in the classroom. Additionally, in a larger sense, it is appropriate to consider recent reforms and research that supports the prevention of these achievement gaps.

## **Implications for Practice**

### *Standards-Based Mathematics Curriculum Reforms*

The data analyzed in the current study was gathered from assessments that measured mathematics achievement on the 2001 Virginia Mathematics SOLs. In 2012, School District A began implementing and assessing students in Grades 3-8 on the mathematics standards that were developed in 2009. In contrast to the 2001 standards, the 2009 Virginia Mathematics Standards are aligned with the Common Core State Standards for Mathematics, which place an emphasis on momentum toward college and career readiness (NGA & CCSSO, 2010). This is noteworthy because the findings from this research are based on testing data prior to the implementation of these standards. The state of Virginia has already adjusted its mathematics curriculum and built in a more rigorous pathway and approach to math instruction. However, as with any adjustment or shift in standards, the key to success and learning outcomes will rely heavily on the practices utilized within the actual classroom.

If the results of the current study are an indication that more attention should be given to

higher-level conceptual learning opportunities, then pedagogical best practices need to be considered alongside the revised mathematics standards to close skill gaps between student subgroups. The selection and use of standards-based curricular and instructional materials with the students is one element of mathematics instruction that might be considered.

The National Research Council (2002) describes mathematics curricular materials as a “channel of influence” for conceptual understand and student learning outcomes. Indeed, when one considers the link between math teacher and student, it is simple to see how the materials utilized function as one of the modes of connection to conceptual understanding. However, the ways in which teachers interact with curricular materials is important. Much of the discussion about mathematics education in the last 10-15 years has concerned standards-based reform practices around the utilization of curricular materials (NCTM, 2000). The provision of new and innovative math materials, in and of itself, does not indicate that teachers will change their traditional teaching styles to facilitate higher-level learning (Manouchehri and Goodman, 2000; Elsaleh, 2010). Lloyd (2009) also suggests that pre-service teachers experience varying degrees of comfort with traditional textbook vs. standards-based materials, perhaps rooted in their own learning of mathematics, and may resort to using varied techniques based on this level of comfort. The current study suggests that Black students could especially benefit from instruction that increases mathematical understanding beyond more basic number sense skills, which was the area of highest relative strength revealed in the strand analysis. Given the diversity in teaching practices when using math materials that correspond with current standards-based higher complexity math curriculum, there is little existing research about specific materials and programs might be particularly helpful in increasing depth of conceptual math knowledge for historically underserved students. There is, however, a base of literature that supports the



influence of specific teacher characteristics and methods on the effectiveness of student learning in the mathematics classroom.

### *The Importance of the Mathematics Teacher*

Recent attention has been given to standards-based reform math teaching methods, or teaching practices in the classroom that place an emphasis on explanation and learning process, rather than rote memorization and execution of simple math procedures. For example, cooperative group learning between students is one popular strategy outlined as effective at increasing understanding of mathematics (NCTM, 2000) when executed correctly. More recently, research has begun to refocus on the attributes and role of the teacher. When considering cooperative student work, Dekker, Elshout-Wohr, and Wood (2006) and Lowrie (2011) note the complex interplay of social dynamics, peer interaction, regulation and integration of perspectives, and task management in these situations, which may have a tendency to influence learning outcomes and product quality. In other words, the power of student-driven collaborative learning is contingent upon the teacher's ability to facilitate the strategy in a way that will enhance learning in spite of mediating factors experienced by the students. This should not be viewed as an attempt to discount the benefits of cooperative learning on mathematics learning and achievement, but rather to support the idea that collaboration between students in the classroom should be utilized proportionally with other teacher-driven teaching practices that promote higher-level understanding. The most current research emphasizes the idea that the teacher is the driving force behind student learning.

It is generally understood that there is no substitute for a highly effective mathematics teacher that possesses both common and specialized knowledge of math, how students learn

mathematics, common misconceptions or misunderstandings that students experience, and how to design instruction that promotes learning of math concepts (Ball, Thames, & Phelps, 2008). The math teacher is the critical link to student understanding of the curriculum, and is the primary facilitator of this process. Cengiz, Kline, & Grant (2011) emphasize the importance of the teachers' role in encouraging mathematical reflection and reasoning, and going beyond simple explanation of solution methods to facilitate student discussion. Exposure to these classroom practices is critical to students moving beyond low-level numeracy and computation knowledge. The results gleaned from the current study suggest that there continues to be a need for our historically disadvantaged and underserved students to experience this type of high quality instruction, surpassing the mastery of basic numeracy skills. In addition to reform-oriented instructional practices, research supports the notion that high expectations for advanced student learning must be emphasized in the math classroom, especially for students belonging to groups at risk for underperformance.

Woolley, Struchens, Gilbert, & Martin (2010) studied the influence of teachers expectations and reform instructional practices on the mathematics learning outcomes of 933 Black middle school students. In this investigation, students with math teachers that had high expectations and standards, as well as those who were exposed to current reform-based instructional practices, reported higher levels of motivation to learn mathematics. The higher level of motivation experienced by the students acted as a positive mediator for the amount of time spent studying, students' expected math grade, and SAT-10 math scores. More importantly than the increase in student SAT scores, high expectations by the teacher influenced the atmosphere in the classroom in terms of creating a positive and supportive social environment for Black students. Of particular note was the nature of the relationship between math teacher

and student, which was based on the communication of rigorous expectations and the achievement of students rising to this challenge. These findings are reminiscent of Flores' (2007) point that high teacher expectations affects student own beliefs about their mathematical ability, which in turn influences their potential to be successful.

Student beliefs about their ability, and the expectations held by their teachers, have consistently been shown to be an important factor in historically underserved students' efficacy and engagement with academics. Tyler and Boelter (2008) found that the perceptions of Black middle school students about teachers' expectations of their classroom performance were significant for predicting efficacy and cognitive, emotional, and behavioral engagement within the classroom. This reinforces the position of Decker, Dona, and Christenson (2007) that the perceived teacher/student relationship by Black students is a critical factor in healthy social emotional functioning and academic engagement. It is therefore relevant to consider the impact of teacher practices with respect to attitudes and beliefs about their students, perhaps even more so than the instructional strategies and curricular materials they utilize in the classroom.

### *Professional Development*

In light of the documented need for teachers to engage not only in implementing methods in the classroom which promote higher level mathematical learning, but also to have high expectations for students at risk for failure, the need for professional development opportunities is critical. Addressing this issue can be challenging, as it involves concurrent adjustments in teaching practices, some of which teachers have been accustomed to for years, and a somewhat dramatic shift in paradigms about the factors that affect student learning and achievement. Facing the notion or suggestion that one has been underserving (or, perhaps, even damaging)

their students can stoke defensive reactions; nobody likes to realize they have been “doing it wrong.” However, Cockburn (2011) calls for conversations about math education and professional development efforts to extend beyond the typical “comfort zone,” which limits professionals’ insight and acts against the overall enhancement of teaching. Some of the challenges involved in teachers being able to adapt to reform oriented teaching methods may lie in a disconnect between the expectations the teachers have of the effectiveness of professional development, and their own view on the applicability of math teaching strategies in their classrooms (Nipper et al., 2011). Nevertheless, given the rapidly evolving nature of our knowledge base about the skills students will need to be successful, the lack of teachers’ own understanding of current math concepts and effective pedagogy may be a factor that is complicating current efforts to reform mathematics education.

Hill, Rowan, and Ball (2005) point out that teachers’ knowledge of mathematics itself is an important predictor of students’ early achievement in mathematics. Additionally, their study accounted not only for the concrete mathematical knowledge of the teachers, but also their knowledge about *how to teach* the content given their own skills. The study also highlights the negative relationship between teacher mathematical knowledge and student achievement in at-risk racial and socioeconomic categories, underscoring the need for historically underserved students to have access to high quality teachers. This echoes points made in research about the tendency for historically disadvantaged students to be taught by lower quality, less knowledgeable teachers (Flores, 2007). However, isolating professional development exclusively to the improvement of mathematical content and teaching knowledge is a one-dimensional approach to a very multi-faceted issue.

Recent research has focused on the need for professional development to incorporate an

awareness of issues concerning equity and culturally relevant learning as a component of strengthening the pedagogical skills of math teachers. Wagner and Foote (2013) note the intersection of mathematics and multi-cultural learning in a professional development program instituted in one school district. Teachers were exposed to the influence of lived experiences while concurrently receiving professional development on mathematics curriculum and pedagogy. When the diverse experiences and learning styles of students were incorporated into professional development activities, the majority of teachers began to think of teaching math in ways that were focused on student understanding, instead of the simple implementation of the curriculum. This research, in combination with the results of the current study, suggests that professional development for math teachers must go beyond simple exposure to the “latest and greatest” math curriculum, instructional strategies, technological software and tools, etc. but also incorporate elements that reflect an understanding of the diverse needs of students that are traditionally at a disadvantage.

The most recent position of the National Council for Teachers of Mathematics (2012) regarding math achievement disparities between traditionally disadvantaged and advantaged populations emphasizes the current thinking about what sorts of supports are needed to close the achievement gap between these groups. The primary point articulated in this position statement concerns pervasive and persistently held low expectations for these at-risk groups. Although lack of access to high quality instructional practices and materials has been a complicating factor, perhaps the most egregious disservice to disadvantaged students has been “...relegating them to low-level mathematics classes, where they repeat work with computational procedures year after year, fall further and further behind their peers in grade level courses, and are not exposed to significant mathematical substance or the types of cognitively demanding tasks that

lead to higher achievement” (NCTM, 2012). The current study confirms the continued presence of the achievement gap between Black and White students, and socioeconomically disadvantaged and advantaged students, as well as suggests that historically underserved students are performing higher in basic math skills relative to more conceptually demanding categories. The link between the Black/White conceptual skill gap is not definitively known, and the most recent research can only suggest what factors might be contributing to the disparities observed in this study. Additional research concerning the current achievement gap, and the factors that play a potential role in its existence, is both appropriate and warranted.

## **Limitations**

As specified in the *Delimitations* sections, this study applies most directly to a narrow cross section of overall students in a specific school division, geographic region, and instructional context. Consequently, there are limitations to the ability of this research to be generalizable to a larger population. The internal characteristics of the study itself also limit the types of information that the data analyses provide, as well as the power of the inferences that can be made when the results are considered.

The data sample obtained for the current study concerns only students in Grades 3-8. Mathematics achievement was, therefore, not measured for students in kindergarten through second grade, or from ninth grade and beyond. This was important to maintain consistency and accuracy in the strand-based analysis. However, this study cannot speak to math achievement at the high school level, the knowledge of which is both important and relevant to understanding the entire picture of the mathematics performance of students as a whole. The current study also only pertained to the mathematics achievement of Black and White students; students from other

racial and ethnic categories were not considered. While these two subgroups of students are the most populous in School District A, and the state of Virginia, this fact does limit the results and inferences exclusively to students belonging to demographic groups. As other populations (i.e. Hispanic students) grow and account for a larger portion of the study body of the school district and state, it will be very important to consider the detailed mathematics achievement of these students as well.

In addition to the sample characteristics of the current research, a limitation also exists with the scope of the study. The data analysis was conducted on student achievement data from one large school division in Central Virginia over the course of three years. School District A is unique in its population demographics and characteristics, and its geographic location. As such, this researcher is uncertain as to whether the results could be generalized to school districts that are located in heavily urban areas or sparsely populated rural regions of the state. The study is also implicitly concerned with data produced by students that have been exposed exclusively to the mathematics curriculum used by the state of Virginia. While the standards of Virginia's curriculum are sufficiently aligned with national mathematics content standards, it is more appropriate to limit suggestions of generalizability to Virginia students. Data was obtained through criterion-referenced assessments that measure proficiency on Virginia-specific mathematics content knowledge, as opposed measures that considers achievement on a national scale.

The current study is limited to the provision of descriptive information only. Data was analyzed and reported, without context or consideration of other factors. Consequently, this research is not analytical or experimental; its ability to gauge the effectiveness of any antecedent strategy or dynamic (i.e. benefit of certain types of teacher training, teacher attitudes, etc.) is

significantly restricted. Instructional pedagogy was not considered as part of the current study. Therefore, no information can be explicitly gleaned about specific classroom practices that would be particularly influential.

Finally, an important part of the teaching and learning process lies not only in identifying the math concepts that posed difficulty and which types of questions tended to be answered incorrectly, but *why* certain answers were chosen instead of the correct ones. The current study only reports on mathematics achievement that is based upon correct answers chosen. No data concerning the incorrect answers selected could be provided. Thus, information concerning the popularity of other answer choices among the sample is non-existent. Provision of this type of data could be potentially useful in attempting to understand processes that students use when answering more complex math questions.

### **Suggestions for Future Research**

The information obtained from the current study only offers a narrow glimpse of the larger picture concerning the state of mathematics achievement between defined student populations (Black vs. White students, socioeconomically disadvantaged vs. advantaged students) at elementary and middle school levels. While this research does echo the established presence of a mathematics achievement gap in historically underserved groups, and further suggests that Black students tend to perform higher with basic math skills, research that considers other variables, data sources, and different contexts is needed to appropriately generalize the results of the study.

As stated previously, the current study concerns mathematics achievement data from assessments that were conducted in 2009, 2010, and 2011. These assessments measure the



implementation of the Virginia mathematics curriculum standards created in 2001. School District A began fully implementing the new Virginia math standards in 2012, after the data from 2009-2011 had been collected. Therefore, research concerning student performance on the newer, more challenging math curriculum would be appropriate. Data gained from this type of study could be compared with data from the current research to obtain information about how students are responding to the shift in curriculum.

Future research in the area of mathematics achievement should also involve data analysis that explores other demographic groups and utilizes different variables. As stated previously, the current study only offers information pertaining to a narrow cross section of possible participants. It would be appropriate for other research to evaluate the performance of students from other ethnic/racial groups, different sociodemographic contexts, varying regions of the state, and other grade levels. For example, it may be worthwhile to explore whether the results of the current study are commensurate with student performance from rural areas of Virginia, or with students from other geographic regions (i.e. comparison between students in Western Virginia vs. Eastern Virginia). Other potential analyses might include different independent variables, such as family income level, teacher education level and/or years of experience, etc. depending on research questions that link student mathematics performance to other factors. Additionally, if variables utilized in the current study were further disaggregated (i.e. “school level” was disaggregated to specific grade level), other analysis methods could be employed. For example, regression analyses conducted on different “cohorts” of students over an increased time span could offer insight into the predictive factors of math performance in certain content areas from year to year.

The limitation of the current study to analyze data concerning incorrect answers selected

by the students was addressed in the *Limitations* section. However, a study examining this topic could provide empirical data on the frequency in which students chose alternate answers, and potentially give insight into common mistakes with mathematical processing. If the data were available, a decoy answer analysis would be beneficial research to conduct. The knowledge that students who answered incorrectly on certain math questions overwhelmingly chose an answer that involved a particularly misunderstood math process may inform teaching practices that prevent these learning errors.

Finally, this researcher would be remiss if it were not emphasized that student achievement in mathematics, and indeed in any content area, will involve a host of factors in addition to student demographic characteristics. The current study does not consider any instructional, school, or classroom-based factors on student performance. Informative future research on mathematics achievement could, and probably should, include some measure of instructional quality, classroom dynamics, student-teacher interaction, etc. as a link between student performance and professional practice. Various assessment systems exist that offer quantitative information concerning the practice-based side of education. For example, the Classroom Assessment Scoring System (Pianta, LaPro, & Hamre, 2007; Hamre et al., 2012) quantitatively measures a variety of student-teacher interaction ratings that have been shown to support instructional quality within the classroom and school setting. More specific to mathematics, the Instructional Quality Assessment (IQA) Mathematics Toolkit measures four distinct areas of “ambitious mathematics instruction,” which the literature identifies as particularly relevant to the needs of historically underserved students: cognitively challenging instructional tasks, opportunities for students to engage in high-level thinking/reasoning, opportunities for students to explain mathematical thinking/reasoning, and teachers’ expectations

for student learning (Boston, 2012). Future research that incorporates these types of data would offer a depth and richness of information, related to actual classroom practice, that data analysis alone is not sufficiently able to provide.

## **Conclusions**

After decades of data collection identifying student achievement disparities, and political efforts to reform associated educational practices, there continues to be an achievement gap between Black and White students, and socioeconomically disadvantaged and advantaged students, in the area of mathematics. Disparities in mathematical knowledge and understanding are thought to be reflective of the disparities in educational opportunity that have existed between the underprivileged and privileged classes throughout the history of American public education. The consequences of unequal access to educational opportunity can be seen generally in multiple aspects of society, from the impact of poverty on public health, to the accessibility of services in rural vs. urban areas, to the economic effect of a workforce that risks being underprepared for 21<sup>st</sup> Century job and career demands. The narrow examination of the achievement gap between disadvantaged students and their more advantaged peers is quite simply one brief glance of the larger issue of equity in education. Many steps have been taken, albeit gradually and with limited investment, to ameliorate the effects of these historical disparities. However, in any effort involving reform and change, the outcome will be dependent not on a fixation with discussion of the symptoms, but rather the specific steps we take to address the roots of the problem.

While recent literature has associated achievement gaps between historically underserved and more advantaged populations with historical factors, societal realities, and disparate

educational opportunities, there is no primary cause that can be isolated. Given the multifaceted nature of this issue, there is also agreement that there is no one “magic bullet” solution to the problem. Nisbett (2010) discusses the efficacy of multiple interventions that address the achievement gap, including early intervention programs. For example, Head Start, as a general programmatic solution to preventing achievement gaps, earns less of a return on investment than preschool programs which target specific cognitive and readiness skills, employ trained and educated high-quality teachers, and provide intensive outside-the-box interventions (i.e. home visits, year round school programming, etc.). In addition to expensive programmatic interventions, the dramatic effectiveness of small, inexpensive, *self-efficacy based* direct support has also been proven (Nisbett, 2010). This suggests that the issue addressed by the current study is about more than “intervention programs” we use with students in school. Our beliefs about teaching and learning, and our children’s beliefs about themselves and their abilities, play an integral role in countering the protracted consequences of our past negligence.

The issue of closing the achievement gap is an important one for our children, and indeed our society as a whole. Now more than ever, we are a country that is dependent on our ability to be competitive on a worldwide scale, in a global economy, with people from other nations who desire the same freedom and security we possess. There are perhaps fewer skills that are more vital to our capability to ensure our success than science, technology, and mathematics. As societal demographics shift, the notion of a workforce comprised of large groups of people having experienced disparate educational opportunities is concerning. Metz (2010) points out that business leaders have called attention to the multiple impacts of a society whose members are ill prepared to satisfy the demands of the marketplace. These include societal liabilities caused by lower incomes, poorer health, and higher incarceration rates. Additionally, hundreds

of billions of dollars in lost opportunity related to Gross Domestic Product output, and associated revenues generated, factor in to these concerns. It stands to reason that the “underutilized human potential” (Metz, 2010) that is born from our current situation will pose challenges for our country that, if left unaddressed, we may not recover from.

It is this researcher’s desire and hope, as an educator, that the information provided by this study will contribute to the established body of research that supports the need for a comprehensive approach to resolving the achievement gap and disparities experienced by minority and economically disadvantaged students. The solution to this problem should involve a combination of shifting paradigms, realignment of priorities, and investment in both education and *people*. The value of data analysis, identification of significant variability, etc. should not be discounted as part of our efforts to understand and interact with the issue. However, without a primarily *people-focused* approach to the solution, we are simply narrating our own decline.

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