Investigating the Achievement Gap in Mathematics:

An Analysis of Fifth Grade School Data

A DISSERTATION
SUBMITTED TO THE FACULTY OF THE GRADUATE SCHOOL
OF THE UNIVERSITY OF MINNESOTA
BY

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IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
DOCTOR OF EDUCATION

Frank Guldbrandsen, Adviser

June, 2014

Acknowledgements

I wish to thank the University of Minnesota for giving me admission to this wonderful Ed.D. doctoral program in Education, Teaching, and Learning. I would also like to thank Dr. Joyce Strand for helping me enormously through this process. Dr. Strand provided me with graduate school scholarship and graduate assistantship funding during the first two years of my doctoral program. I would also like to thank Minnesota Minority Partnership who hired me as a policy fellow, which allowed me to work with the school districts of Minnesota and also taught me to explore how the K-12 education system works in the practical world. I am grateful to Dr. Julia Williams for teaching the best class on Assessment and Evaluation; without her class, I would not be able to think about my dissertation the way I do now. I am also thankful to Dr. Randy Hyman, who guided me through this process with his prudent knowledge and experience in educational policymaking.

My heartiest thanks goes to my advisor, Dr. Frank Guldbrandsen, who guided me and taught me enormously throughout every step of this process. Without him, my learning would have remained incomplete. With his deep insights and expertise in the area of education, teaching, and learning, he taught me how to investigate the philosophical perspectives of research in education. He gave me immense assistance to think critically and accurately through the entire process. I am also grateful to Patricia Greenwood, who in a short span of time, has helped me complete editing this document .

I would also like to thank all the members of my committee: Dr. Diane Rauschenfels, whose positive thinking and support helped me to get up and move forward at times when I felt hesitant. I am immensely grateful to Dr. Terrie Shannon for serving on my committee. She taught me the skills of presentation and writing an academic paper. I am also very grateful to Dr. Carmen Latterell as an outside member of the committee. They provided me room to grow and think.

I want to show and express my heartiest gratitude to Dr. Jim Angermeyr, former director of research and assessment, Bloomington Public Schools. He helped me through the entire process of reviewing my methodology and data analysis section. His positive comments and feedback encouraged me and made me believe in my statistical knowledge.

The most important form of appreciation and support I have received is from my family: my husband Sandeep and my two-year-old daughter, Annaysha. The delicious meals prepared by my husband and his constant encouragement allowed me to finish this dissertation. My daughter always knew that mommy was doing her work and she, instead of distracting me, would sit next to me and play in her own with her books and toys. Her sparkling eyes and bright smile provided me the hope and strength to move forward. I acknowledge all my former school-teachers in India, Mr. Asok Sen in particular, who always nurtured my curiosity, infused my passion in education, guided me to a lifelong learning path, and tirelessly taught me how to keep an open mind to new learning and ideas. Mr. Sen always helped me to stay focused to my goals, yet challenged me with contradictory philosophical-beliefs in life, which made me learn that life is all about a balance and harmony.

I am immensely thankful to my friend Prachee Mukherjee; without her, I would not have been able to finish this dissertation. She brought with her rays of hope and encouragement and taught me never to give up, even during the most difficult moments. I also like to thank all my friends who have shared much desired fun and humor through the entire process. It is difficult to choose a few from many in Terre Haute, who helped immensely at various capacities during the final process of my dissertation submission. Of which Dr. Liz Brown, Dr. Jon Hawes and his wife Lisa, Dr. Ashish and Chandrama Chakraborty deserves special mention.

Dedication

I remember once my father told me two things: A pen is mightier than a sword, and writing a dissertation is like giving birth to a baby. Through my experience in writing this dissertation, I couldn't agree more to his words. No matter how much we argue with an agenda, no matter how much we try to convince people with an issue, it is difficult implementing unless we research, write, and articulate our findings. We can make people see our world through writing. Researching a topic and writing about it is the best way to explain an agenda to others.

Before a baby sees the light of an outside world, it gets nourished and nurtured each day inside a mother's womb. Similarly, a dissertation, like a baby, also gets nurtured and nourished through the writing process and takes shape after a certain time period. Unlike giving birth to a baby, the process of writing a dissertation may seem never-ending, but still it takes birth through research, writing, and editing.

My mother taught me that research means to *re-search*, redo, and look for something repeatedly. How can I forget the support and dedication she provided me during my doctoral years? We lived thousands miles apart, still she was always with me. Her sacrifice is unparalleled. Even when she was in a critical condition, she asked me not to visit her, instead, finish my orals, continue with my dissertation, and not worry about her. She could not live up to this day to see this moment of fulfillment, but my deepest gratitude and sincere acknowledgement of her inspirations goes to her.

I want to dedicate this dissertation to my father, Monoranjan Banerjee, my mother, Arati Banerjee, and Atmaja B. Bhowmick; all of them, in some ways or other, gave up their lives to help fulfill my dream.

Abstract

The problem of the achievement gap gained widespread attention after the initiation of the No Child Left Behind (NCLB) Act of 2001 (U.S. Department of Education, 2002). According to NCLB, schools, districts, and state educational systems are required to meet annual targets for improvement in identified academic areas (mathematics, reading, and science), not only for their student populations as a whole, but for several identified subgroups: (a) Black, (b) Hispanic, (c) white, (d) economically disadvantaged, (e) special education students and (f) limited English proficiency (LEP). Schools, districts, and states were seen as ultimately accountable for the achievement rate of any of these subgroups of students. The purpose of this study was to use the concept of an education production function to measure students' current year performance in mathematics (output, measured by test scores) as a combination of inputs: (a) students' previous year's test score, (b) teacher quality (measured by National Board Certification), (c) socioeconomic status (measured by free and reduced lunch population), (d) school setting (urban, suburban), and (e) student demographics (measured by ethnicity and special needs student population). To analyze these relationships, this study utilized quantitative methods, particularly multiple regression analysis. The results show that students' current year performance in mathematics is significantly related with students' previous year's performance, socioeconomic status, and student demographics defined by special needs population. A statistically significant relationship was also found between students' academic performance in mathematics and ethnicity. Teacher quality measured by National Board Certification has significant influence on students' academic performance in mathematics. Looking at urban and suburban school setting, results show that there is

not any significant relationship with students’ academic performance in mathematics and school setting.

Table of Contents

List of Tables

Table Page

List of Figures

Figure Page

Chapter 1. Introduction

Introduction to the Problem

According to the U.S. Department of Education, the achievement gap is defined as the difference in academic performance between different ethnic groups. The problem of the achievement gap gained widespread attention after the initiation of the No Child Left Behind (NCLB) Act of 2001 (U.S. Department of Education, 2002). According to NCLB, schools, districts, and state educational systems are required to meet annual targets for improvement in identified academic areas (mathematics, reading, and science) not only for their student populations as a whole, but for several identified subgroups: (a) Black, (b) Hispanic, (c) white, (d) economically disadvantaged, (e) special education and (f) limited English proficiency (LEP)Schools, districts, and states were seen as ultimately accountable for the achievement rate of any of these subgroups of students.

Under the NCLB (U.S. Department of Education, 2002), standardized tests are used to measure the performance of students across different ethnic groups from third grade through twelfth grade. The Minnesota Comprehensive Assessments (MCAs) are a series of tests used in Minnesota to measure student performance across different ethnic groups (Minnesota Department of Education, 2012b). These are tests which are given by Minnesota schools every year to measure student performance on Minnesota state standards. These standards outline what students in Minnesota should know and do in a particular grade. Schools use the information from these tests to improve teaching and learning. Teachers and principals look for areas where students do well. They can reinforce the ways they teach these skills. They also look for areas that need improvement.

Minnesota is one of the highest performing states in standardized tests, but it is also one of the states in the nation with the highest achievement gap. The achievement gap in Minnesota has widened over the years (National Center for Education Statistics, 2011). The MCA test results for 2012 revealed the fact that only 32.6 % of Black students, 38.5% of American Indian students, and 38.2% of Hispanic students are proficient in mathematics compared to 68.4% of their white peers (Minnesota Department of Education, 2012a). Hassan and Mahmoud (2011) categorized the achievement gap as actually five gaps: (a) the preparation gap, (b) the belief gap, (c) the time gap, (d) the teaching gap, and (e) the leadership gap.

The preparation gap. Even before children are of school age, differences exist across various developmental aspects of children, such as appreciation of arts, language, personal and social skills, mathematical thinking, and physical development. However, children with low household income and with less educated parents are likely to have lower school-readiness ratings. School readiness also depends on a child's economic situation, home environment, emotional, social, and physical health, and cultural identity. All these factors combined together influence achievement in school (Hassan & Mahmoud, 2011).

The belief gap. The achievement gap depends on the degree to which students, parents, teachers, and the community believe it could be addressed and solved. However, such belief is also difficult to come by until a significant outcome is achieved. School districts follow only when the gap is significantly reduced or closed in one district. Also, students' effort and performance are strongly influenced by teachers' beliefs and expectations (Hassan & Mahmoud, 2011).

The time gap. Many children of color have fallen behind grade level. In order to successfully address this shortfall, more focused time on learning during the school day is required. Some researchers believe that longer school days and school years might be a solution to this problem, and students provided with significant more time for teaching and learning can reduce the gap. In this light, after-school and summer programs are considered critical elements to reduce the time gap (Hassan & Mahmoud, 2011).

The teaching gap. The teaching gap is considered to be the most important factor behind student success. Good quality teaching is a primary strength of good schools. Students who are taught by several effective teachers in a row perform well, compared to students who are taught by ineffective teachers. Hence for children at risk with high achievement gap, strong teaching is found to be most critical (Hassan & Mahmoud, 2011).

The leadership gap. Besides effective teachers, the next most important factor is the leadership in the schools. The role principals and school leaders play on student outcomes can never be overestimated. Schools led by effective school principals and district superintendents are also found to be most successful in closing the achievement gap (Hassan & Mahmoud, 2011).

Closing the achievement gap is an important issue because of its direct impact not only on individual students, but also on the community and the nation as a whole. When a group of students is not educated fully, higher dropout rates and a negative impact on the economy, among other things, can occur. In order to improve the economy and increase human capital it is essential to have a well educated population (Barber & Mourshed, 2009).

Background of the Problem

In 1965, President Johnson proposed the Elementary and Secondary Education Act (ESEA) (U. S. Department of Education, n.d.). Encompassing Title I, ESEA intended to provide equal access and to establish high standards in education. In 2001, President Bush introduced NCLB as a reauthorization of ESEA. Under NCLB, schools, districts, and states have had to follow a number of measures. With the main objective to increase student achievement and to hold states and schools more accountable, the following measures, under NCLB, became mandatory for schools to follow.

Annual testing. Testing students in grades 3-8 annually in reading and mathematics became necessary for schools by the year 2005-06. By school year 2007-08, states had to test elementary, middle, and high school students in science at least once. All these tests had to be consistent with state academic standards. To provide a point of comparison for state test results, a few fourth and eighth graders in each state were also sampled each year to participate in the National Assessment of Educational Progress (NAEP) testing program in reading and mathematics.

Academic progress. By the 2013-14 school year all states are required to bring all students up to the “proficient” level on standardized tests. This implies that individual schools have to meet “adequate yearly progress” (AYP) targets toward this goal (AYP is measured using an equation specified in law) for overall student populations and for subgroups from specific demographics. If schools with federal Title I funding fail to meet AYP two years in a row, they are provided technical assistance and their students are offered a choice of other public schools to attend. Students in schools that fail to make adequate progress three years in a row also are offered supplemental educational services, including private tutoring. For continued failures, a school is subject to outside corrective measures, including possible governance changes.

Report cards. From the 2002-03 school year, states were required to furnish annual report cards which included student-achievement data broken down by subgroup and information on the performance of school districts.

Teacher qualifications. Teachers teaching in core content areas had to be "highly qualified" by the 2005-06 school year. Teachers certified and proficient in respective content areas are considered to be "highly qualified." Beginning with the 2002-03 school year, all new teachers hired with federal Title I money are required to be "highly qualified." By the end of the 2005-06 school year, all school paraprofessionals hired with Title I money must have completed at least two years of college, obtained an associate's degree or higher, or passed an evaluation to demonstrate knowledge and teaching ability.

States are required under NCLB to provide detailed breakdowns of student achievement results for racial and ethnic minorities; states for the first time explicitly provided plans to alleviate intergroup disparities (Ferguson, 2007). Improving the quality of inner city schools was an important aspect of pursuing these goals. It was required by law that suburbs should perform equally well. In the year 2000, the U.S Census Bureau (2012) reported that 33% of the nation's Black children[1], 45% of Hispanic children, 54% of Asian children, and 55% of white children live in suburban communities. Some of these children attend poor, segregated schools similar to many of the poorest schools in the inner city and others attend racially integrated schools in well off communities where resources are relatively abundant and schools have excellent reputations (Ferguson,

[1] In this study children of African American origin are referred to as Black children.

2007). A larger number of children are affected by the achievement gap. A huge body of researchers and educators are trying to diagnose the root cause of the achievement gap and eliminate it. Since there is no single factor which causes the achievement gap, efforts to solve this problem have been multifaceted.

The causes for the achievement gap are complex. According to a group of researchers (Barton, 2003; Bennett et al., 2004; Campbell & Levin, 2009; Carey, 2002; Duncan, Featherman, & Duncan, 1972; Evans, 2004; Fan & Chen, 1998; Griffith, 1996; Lee & Bowen, 2006; Smith, 2006), they fall under two main categories, one of which is related to students' socioeconomic status, cultural environment, and family background; the other is related to students' schools.

Several researchers established a correlation between student academic achievement and socioeconomic status (Duncan & Magnuson, 2005; Evans, 2004; Reardon, 2011; Sirin, 2005). Some other research studies established school factors as the main cause of the achievement gap (Griffith, 1996; Hanushek & Woessmann, 2007; Konstantopoulos, 2006).

Education Production Function

Several researchers have constructed education production functions to investigate the factors behind student performance (Hanushek & Woessmann, 2007; Houtenville & Conway, 2008; Marcotte, 2007). An education production function is based on the concept of production function and it is an application in the field of education. It measures the relationship between the output of the educational process, the achievement of individual students, and related inputs which both are either directly controlled by policy makers (e.g., the characteristics of schools, teachers, curricula) or indirectly controlled by families, friends, innate endowments, or learning capacities of the students. Though achievement can be measured at discrete points in time, the educational process is cumulative; inputs applied sometime in the past affect students' current levels of achievement (Hanushek & Woessmann, 2007). Inputs that are related to school typically include teacher background (education level, experience, sex, race, and so forth), school organization (class sizes, facilities, administrative expenditures, and so forth), and district or community factors (average expenditure levels, per-capita student expenditure and so forth). Generally, statistical analysis is employed to determine the importance of various inputs into student performance (Hanushek & Woessmann, 2007).

Ninety publications that appeared before 1995 included 377 separate production function estimates. Among these 377 separate production function estimates, 9% of the research accounted teacher education as one of the important classroom resources whereas 14% of the research estimated student-teacher ratio as an important variable for student achievement. Both these research have yielded a positive and statistically significant relationship between student performance, teacher education, and teacher-student ratios(Hanushek & Woessmann, 2007).

There is a general acknowledgement that promoting teacher quality is one of the key factors in improving student achievement in the United States (Harris & Sass, 2009). Research is fairly conclusive that National Board Certified teachers (NBCTs) have significantly higher student achievement scores than non-NBCTs (Cavalluzzo, 2004; Goldhaber & Anthony, 2007). Research also shows that students taught by board certified teachers consistently see the highest gains in achievement (Vandevoort, Amrein-Beardsley, & Berliner, 2004).

Though there is a general disagreement about what a highly qualified teacher is, there is no disagreement that NBCTs are more qualified compared to the teachers who are not certified. Research also shows that NBCTs, regardless of their ethnicity, are more successful with students of color in comparison with noncertified teachers (Clotfelter, Ladd, & Vigdor, 2007; National Research Council, 2008). Data from the National Board for Professional Teaching Standards (NBPTS) website show that in 2011, 6,266 teachers became NBCTs through NBPTS which increased the total number of NBCTs nationwide to 97,291 (NBPTS, 2013c). These accomplished teachers comprise approximately 3% of the national teaching force, more than half of whom teach in high-need schools, and 15% are certified in science, technology, engineering, and mathematics (STEM)-related areas. In 2012, there was a 10% increase in the number of teachers earning certification over the prior years. Hence, 19 states have more than doubled the number of NBCTs in the past five years. In Washington and Wyoming, NBCT populations have more than quadrupled in the past five years. However, in Minnesota the total number of NBCTs is 377, of which 11 were certified in the school year 2011-12.

Statement of the Problem

Not enough is known, whether student performance in mathematics is affected by the independent impacts of teacher quality, socioeconomic status, student demographics, and school characteristics or joint impact of these variables.

Purpose of the Study

The purpose of this study is to use the concept of an education production function which will measure student performance (output) as a combination of inputs: (a) students' previous year's test scores, (b) teacher quality (measured by National Board Certification), (c) socioeconomic status (measured by free and reduced lunch population), (d) school setting (urban and suburban), and (e) student demographics (measured by ethnicity and special needs student population).

Research Questions

1. Is there a relationship between student performance in mathematics and Nationally Board Certified teachers?

2. Is there a relationship between current year performance in mathematics and previous year's performance in mathematics for different cohorts in the same school and grade?

3. Is there a relationship between student performance in mathematics and socioeconomic status?

4. Is there a relationship between student performance in mathematics and urban vs suburban schools?

5. Is there a relationship between student performance in mathematics and ethnicity?

6. Is there a relationship between student performance in mathematics and special needs student population?

Hypotheses Based on Research Questions

Hypothesis 1: There is a positive relationship between National Board Certified teachers and student achievement in mathematics.

Hypothesis 2: There is a positive relationship between students' current year performance in mathematics and previous year's performance is mathematics

Hypothesis 3: There is a negative relationship between socioeconomic status and student achievement in mathematics.

Hypothesis 4: Achievement of students in suburban schools are higher than urban schools.

Hypothesis 5: Special needs students perform poorly in mathematics.

Hypothesis 6: Black students perform poorly in mathematics.

Hypothesis 7: American Indian students perform poorly in mathematics.

Hypothesis 8: Hispanic students perform poorly in mathematics

Proposed Methodology

The researcher has used quantitative modeling (Blaikie, 2000; Creswell & Plano Clark, 2007) for examining the underlying relation between student achievement and (a) teacher quality, (b) socioeconomic status, (c) school characteristics (urban vs. suburban), and (d) student demographics. In this case, multilevel modeling might be the appropriate quantitative strategy since this technique allows the educational researchers to more appropriately model data that occur within multiple hierarchies (i.e., the classroom, the school, and/or the district) (O'Connell & McCoach, 2008). However, in this study due to unavailability of data at classroom level, factors related to schools and teaching it was not possible to use multilevel modeling. Hence, multivariate regression analysis is used for this study.

Significance of the Study

Studies emphasizing student achievement as a function of teacher quality, socioeconomic status, school characteristics, and student demographics are not common in the field of education, teaching, and learning. Most of the studies have defined student performance as a function of socioeconomic status, school characteristics, or teacher quality. Unlike previous studies, this study is proposing the possibility of using the concept of education production function to examine the factors or inputs, which affect student performance.

Chapter 2. Literature Review

Overview of Achievement Gap

The achievement gap is the differences in academic performance between various student groups. However, this gap frequently refers to disparities in performance between students of color and their white peers. This disparity is visible in various outcome measures: standardized-test scores of students, their overall grades, course choices, college-completion, and drop-out rates.

Compared to most other states, Minnesota students as a whole performed better in standardized tests, college entrance examination, and graduation rates. However, disturbing trends emerge when performance measures are broken down across several demographics groups: (a) the achievement gaps between different demographic groups in Minnesota are one of the largest in the nation, and (b) poorly performing groups are growing the fastest (African American Leadership Forum, 2011), worsening the performance gap further. National education statistics show that the average scaled score of Minnesota in reading and mathematics is above the national average, but surprisingly it also had the highest achievement gap between whites and students of color.

Though Minnesota's white students score in mathematics and reading is second highest in the nation compared to their peers in other states, Black students' scores were ranked 43rd in the nation. In 2003, the NAEP fourth grade average reading score for white students was 224 whereas the average Black students' score was 191. A report from The Education Trust (2006) showed that this discrepancy in NAEP test scores between white students and Black students placed Minnesota among the bottom eight states for the achievement gap in reading. For NAEP eighth grade mathematics, the average white students' score was 293, which placed Minnesota second in the nation to Connecticut, whereas the average Hispanic students' score of 260 placed Minnesota 15th in the nation. According to the Minnesota Department of Education (2012a), reading performances of Black and Hispanic fourth grade students were almost three grade levels below their white counterpart. On state mathematics tests (MCAIIs), 55% of white eleventh grade students scored proficient, while only 16% of Black students and 22% of Hispanic students were scored proficient in the same test. The same test result released in the year 2012 shows that 11.5% of the Black eleventh grade students are proficient in mathematics (Minnesota Department of Education, 2012a).

The performance of Black students on state level and national assessments tests continues to lag behind their white peers. The NAEP data collected on instructional practices indicated the difference in teaching white students and non-white students. Empirical evidence suggests that instructional guidance set forth by National Council Teachers of Mathematics is not always available to minority students (Johnson & Kritsonis, 2006).

Many researchers have documented facts about the achievement gap in the United States. Using proficiency data compiled from U.S. Department of Education annual reports for grades 4 and 8 in reading and mathematics assessments, Blank (2011) argues that for two thirds of the reporting states, fourth graders' reading assessments for economically disadvantaged students showed noticeable improvement; however, eight of these states could significantly reduce their achievement gap. Between the time periods 2005-06 to 2008-09, economically disadvantaged students in 20 states scored 5% above the state's proficiency level. Of 40 states for which consistent data were available for the four-year period (2005-09), eight states showed no positive achievement gain on the state level reading assessments; however, a few states such as Arizona, Arkansas, California, Maine, Nebraska, Nevada, and South Carolina could actually achieve more than 10% gain in the NAEP test scores. Though the results indicated that most states had gains in achievement for economically disadvantaged students, a smaller number of states could actually close the achievement gap for these students.

Similar patterns emerge for the eighth grade mathematics assessment results. Extant findings show that mathematics performance improved from 2005-06 to 2008-09 in over three fourths of the reporting states, and one third of the states did close the achievement gap for the targeted population (economically disadvantaged students). Of the 44 states for which trends could be analyzed between school year 2005-06 to 2008-09, 33 states gained more than 5% in number of eighth graders meeting proficient level in mathematics. During the time period 2005-09, proficiency level increased by 15% for economically disadvantaged students in the District of Columbia, Arkansas, Michigan, New Mexico, New York, North Carolina, and Virginia. Non-trend data comparing 2005 to 2009 for NAEP fourth grade reading scores show significant gains in performance of economically disadvantaged students for over half the states, while 10 states could actually close the achievement gap.

Trend data for percentages of students from economically disadvantaged background showed gains of more than five percentage points for 27 states. Several states, including Connecticut, Delaware, Hawaii, Rhode Island, Missouri, and Maryland, improved on NAEP reading at or above the basic level by more than 10 points. Trends in NAEP eighth grade mathematics scores suggest significant gains in performance for the targeted group (economically disadvantaged students) in 20 states, with 10 states being able to reduce achievement gap. Similarly, NAEP eighth grade basic level mathematics scores of the targeted group showed gains by 5% or more in 20 states. Several states, such as Florida, Maryland, Nevada, New Jersey and Rhode Island performed even better by improving more than 10 points in basic level NAEP mathematics. Even though gains in NAEP test scores in eighth grade mathematics were made for over four years (2005-09), the results for economically disadvantaged students when taken together for all states suggest deterioration from 35-55% in NAEP basic level grade 8 mathematics. Blank's (2011) research showed that though there was an improvement of mathematics test scores of students, the achievement gap in mathematics has increased over the years.

Reardon and Galindo (2009) compared Hispanic students to their non-Hispanic white counterparts. They observed that Hispanic students have much lower average mathematics and reading skills at the kindergarten level. This score narrows by roughly a third in the first two years of schooling and then remains relatively stable for the next four years. Students who do not have English as their primary language (particularly for first generation immigrants where English is not spoken at home) have the lowest mathematics and reading skill levels at kindergarten entry compared to white students, but they show the highest achievement gains in the early years of schooling. Several researchers have attributed the white and Hispanic achievement gap to socioeconomic status, English proficiency, and school quality, of which the "family socioeconomic status is found to have the largest impact on student achievement" (Reardon & Galindo, 2009).

Ford (2010) investigated how students from different races, languages, social classes, and communities encounter disparity in the quality of school experiences. The quality of education received by students from the low socioeconomic status and ethnic minorities is affected by systemic issues. Chatterji (2005) estimated the mathematics achievement gaps in different subgroups of kindergarten and first grade students. A subset of 2,300 students from the Early Childhood Longitudinal Study K-first grade data set was analyzed with hierarchical linear models. At the end of kindergarten, considerable mathematics achievement gaps were found in Hispanic, Black, and high poverty students. However, at the end of first grade, mathematics achievement gaps were more significant amongst Black, high poverty, and female students but not in Hispanics. The factors attributed towards this gap were class size, at-home reading time by parents, and school size. Cross level interaction at first grade indicated that schools with larger class and school sizes had a negative effect on Black students' mathematics scores. Schools that gave more instructional time had positive effects on high poverty students' scores, and schools with higher elementary teacher certification rates had positive effects on boys' mathematics achievement.

The debate on closing the achievement gap of minority students and low income families focuses on several variables including high standards, challenging curriculum, teacher education, and other factors which are related to school administration. However, focusing on few specific variables (commonly available) or using research methods at a broad, descriptive level, many of these studies lack the scientific rigor that examine a comprehensive theoretical domain through the lens of meticulous, quantitative accuracy. The purpose of this study is to use the concept of education production function, for measuring student performance (output) as a combination of inputs: (a) students' previous year's test score, (b) teacher quality (measured by National Board Certification), (c) socioeconomic status (measured by free and reduced lunch population), (d) school setting (urban, suburban), and (e) student demographics (measured by ethnicity and special needs student population).

Education Production Function

In economics, production function is used to determine the optimal level of inputs required to produce the maximum amount of output. Education production function is the pedagogical (technical) process, which helps us to understand the way resources or inputs are combined to obtain the desired or optimal level of educational output. It might be used to find whether there is a systematic relationship between student productivity and various school inputs. A production function relating various group of students' academic performance to school inputs provide a better indication of why different groups of students perform differently.

The literature on education production function falls under two different categories. One group uses independent variables and has a more general focus, and the other group focuses more narrowly on a unique experimental variable. Studies of the latter type include Borg and Shapiro (1996), who focused on student personality type, Cohn, Cohn, and Bradley (1995), who focused on measuring working memory, Anderson, Benjamin, and Fuss (1994), who focused on a myriad of detailed academic indicators, Charkins, O'Toole, and Wetzel (1985), who focused on teaching styles versus learning styles, and Fraas (1982), who focused on instruction using simulation.

Hanushek and Woessmann (2007) used an education production function to model the achievement of individual students. The achievement of students is directly related to inputs, which are directly controlled by policymakers (e.g., school characteristics, teachers, curriculum) and indirect inputs that are not controlled by policymakers such as families and friends or learning capacities of the students. Hanushek and Woessmann's (2007) research confirms the fact that education is a cumulative process where inputs applied sometime in the past affect students' current levels of achievement.

Gyimah-Brempong and Gyapong (1991) used data from school districts in Michigan to investigate whether socioeconomic status contributes significantly to the production of educational outcomes in ways that are independent of their effects on school resources. The findings show that socioeconomic status has significant impact on education output which is independent of school resources.

Houtenville and Conway (2008) investigated an important factor in student achievement and parental involvement. Using data from the National Education Longitudinal Study (NELS), the authors estimated a value-added education production function including parental effort as an input. The results suggest that parental effort has a strong positive effect on achievement that is largely relative to the effect of school resources and is not captured by family background variables.

In the economics of education, it is often difficult to identify the relationship between school inputs and student performance due to the endogenous nature of school resources. The amount of instruction students receive from teachers in a given school year is an important component of student performance. Marcotte (2007) examined the effect of instructional time using education production function. Winter weather variation was the chosen variable to identify the impact of schooling on test scores and the number of school days students received prior to taking the Maryland School Performance Assessment Program (MSPAP) examination. The results show that students taking exams in years with heavy snowfall performed significantly worse than their peers in the same school who took the MSPAP examination in other years. Coates (2003) used education production function to examine the correlation between instructional time teachers spend on each subject and student performance. Data were collected on the minutes of instruction per day in each of four subjects taught in the public elementary schools in Illinois. The results indicated that time spent in mathematics and English instruction paid off in terms of improved mathematics and reading test scores. There was also evidence that time spent in social studies instruction raised reading and writing scores. Both these findings were consistent with the interpretation that education inputs in the form of instructional days and time improve students' test scores.

Fertig and Wright (2005) used data from 31 countries participating in the Program for International Student Assessment (PISA) to estimate education production function for reading literacy. The results showed that besides instructional time, class size is an important variable to determine student achievement in reading.

There is a difference in infrastructure between developing nations and developed nations. School inputs (classroom size, student-teacher ratio, school buildings) in developing nations are of poor quality compared to developed nations where school inputs are of high quality. Heyneman and Loxley's (1983) findings show that school inputs have predominant influence on achievement. However, Harris (2007) implemented various tests using data from 32 countries to observe the marginal effects of school. In his study, the marginal effects of school inputs are found to be frequently negative.

Teachers' influence on student achievement is central to educational research. It is important to examine the effect of teachers on student achievement in successive grades. However, the research evidence about teacher effects on student achievement is mixed. Some education production function literature suggests that the effects of observed teacher characteristics on student achievement are negligible, while others consider teacher characteristics as one of the key component of student achievement (Greenwald, Hedges, & Laine, 1996; Hanushek & Rivkin, 2006). There are other studies which have consistently documented that teachers differ substantially in their effectiveness, measured as between-classroom variation in student achievement (Nye, Konstantopoulos, & Hedges, 2004; Rivkin, Hanushek, & Kain, 2005).

Konstantopoulos (2011) examined the continuing benefits of teacher efforts on student achievement in early elementary grades. He was interested in determining the persistence of teacher efforts in early grades and whether teacher efforts remain strong predictors of student achievement or fade over a four-year period from kindergarten through third grade. The findings confirm that teachers significantly affect reading and mathematics achievement, not only in the current or the following year, but in subsequent years as well. However, the results also show that teacher effects estimates in lower grades are smaller than estimates in later grades. Students who receive effective teachers in three consecutive grades, kindergarten through second grade, would experience an increase in their achievement in third grade reading. These effects are considerable and comparable to achievement increases caused by cumulative effects of small classes in early grades.

Several researchers claim that smaller class size and high level of academic achievement are correlated with each other. Babcock and Betts' (2009) analysis answers the question whether reduced class sizes boost achievement mainly by helping teachers impart specific academic skills to students with low academic achievement or by helping teachers engage poorly behaving students. The analysis uses the grade 3 to 4 transition in the San Diego Unified School District as a source of exogenous variation in class size (given a California law funding small classes until grade 3). Results indicate that elicitation of effort or engagement, rather than the teaching of specific skills, may be the dominant channel by which small classes influence disadvantaged students.

Endogeneity problems arise while measuring the correlation between student characteristics and school inputs. These correlations are mainly the result of student stratification between schools. From a statistical point of view, the correlations between student and school characteristics imply that the omission of some variables may generate endogeneity bias. Hanchane and Mostafa (2012) explored endogeneity problems in a multilevel estimation of education production function and suggested an estimation approach technique to tackle bias and to generate consistent estimates. This analysis can be extended to any multilevel-structured data (students nested within schools, employees within firms, firms within regions, etc.).

Understanding the Achievement Pattern of Different Groups

Mathematics achievement varies across race, economic class, gender, ethnicity, and language proficiency. National trends on college admission examinations and advanced placement tests show significant differences in mathematics performance across various ethnic groups. Although Black students tend to perform equally well at basic mathematics skills, performance gaps increase significantly at higher level of mathematics (Secada, 1992). Examining the achievement gap in reading and mathematics from kindergarten through fifth grade, Burchinal et al. (2011) conclude that family, child care, and schooling experiences are the primary reasons for such differences.

Despite an increase in overall NAEP scores for both Black and white students in grade 8 and grade 12 from the years 1998 to 2000, Lubienski (2001) concluded that racial difference combined with lower socioeconomic status remains a major factor in explaining the differences between Black and white students' test scores. However, socioeconomic status as the only explanatory factor often remains inadequate in explaining the performance gap between racial groups. White students with lower socioeconomic status are found to perform better than high socioeconomic status Blacks. Classroom experiences and attitude towards mathematics are also found to be other major factors in explaining the performance differences between races.

Tate (1997) examined mathematics achievement of different social groups defined along lines of race, class, gender, ethnicity, and language proficiency. He reviewed literature on national trend studies, college admission examinations, and advanced placement tests. The literature showed significant differences in mathematics performance of various ethnic groups. Though a study of Secada (1992) showed that the achievement gap of Black students appears to narrow at basic skills mastery, they are not having mastery at higher level mathematics. White and Asian American students have a higher level of achievement compare to Black and Hispanic students. Tate (1997) attributed this to the socioeconomic status of the students. He mentioned that students with high and middle socioeconomic status enter school with higher achievement levels and perform better compared to students with lower socioeconomic status. Leder's (1992) study on gender and mathematics achievement showed that gender differences in mathematics exist as early as the primary level. This trend changes more as they reach the secondary level where male students in most of the cases perform better on standardized achievements compared to female cohorts. He also found that gender differences depend on the format and the level of test. However, Tate (1997) showed that racial, ethnic, socioeconomic status, and language proficiency differences in mathematics were more pervasive than gender differences. It is also evident from Educational Testing Service findings that more than 80% of teachers in schools with middle to upper socioeconomic status students received all or most of the materials or resources they requested for instructional purposes, whereas only 41% of teachers in schools with the largest concentrations of low socioeconomic status students received all or most of the instructional materials they requested (Tate, 1997). This study observed that teachers' mathematics instruction predominantly emphasize on whole-class lectures, with teachers offering a single method of problem solving and students listening to that method. Afterwards students were told to practice individually. Students from lower socioeconomic status at times become shy to ask questions in classrooms and they ended up sitting idle in class rather than solving the problem by themselves. The end result was poor performance in standardized mathematics tests. Though many equity models in mathematics education borrow learning constructs from national and international testing program, these models frame equity as the overlap of content taught and content tested and ignore the influence of cultural factors on student learning (Tate, 1997).

Burchinal et al. (2011) examined the Black/white achievement gap in reading and mathematics from kindergarten through fifth grade. The results of this study showed that family, child care, and schooling experiences largely explain differences in achievement between Blacks and whites. In addition to this, instructional quality plays a major role in explaining the poor performances of Black students. The findings of this study suggested that early intervention at home and school is essential to eliminate the Black/white achievement gap.

Lubienski's (2001) study, using the 1990 and 1996 NAEP data, highlighted the disparities between Black and white mathematics performance and classroom experiences. Though the overall NAEP scores increased for Black and white students in grade 8 and grade 12, race and socioeconomic status differences remained constant in explaining the differences in test scores between Black and white. This study also found that low socioeconomic status is not the only explanatory factor in Black and white performances. It was observed that white students with low socioeconomic status scored higher than the Black students with high socioeconomic status. Classroom experiences and attitude towards mathematics also played a major role in explaining the differences.

The relationship between student academic achievement and socioeconomic status gained prominence with the publication of the Coleman Report in 1966 (Coleman et al., 1966). Family income and parental educational attainment are considered two important key measures of socioeconomic status. With an increase in income gap between high- and low-income families – families at the 90^{th} percentile of national income distribution (about $160,000 in 2008) compared to those at the 10^{th} percentile (about $17,500 in 2008), the achievement gap measuring average reading and mathematics skills also widened significantly between students from these income classes. Undoubtedly, many high-income families invest more in cognitive development of their children, resulting in higher academic achievement compared to their low-income counterparts (Reardon, 2011).

Evans (2004) indicates that socioeconomic differences primarily emerging from income differences create innumerable hindrances for student performances. Students' performances are affected by two major environmental challenges: (a) physical environmental challenges which include greater exposure to health risks, poor quality of housing, and environment; and (b) social environment challenges, which include fewer books and educational materials available at home, fewer household routines, greater incidence of family disruption, violence, and separation from family, less exposure to multiple forms of cognitive stimulation and enrichment, more exposure to television, less verbal responsiveness, less parental involvement in education, both at the school and in the home, and low sense of belonging to school.

School environments differ among children from low-income families and their more affluent peers (Barton, 2003; Bennett et al., 2004; Carey, 2002; Evans, 2004). These studies found that schools with large number of low-income children were more likely to have lower per pupil expenditures, lower teacher quality, less rigorous curriculum, lower expectations for academic performance and fewer demands to enroll in rigorous course work, and lower parental involvement in terms of volunteering in the school, attending school functions, and being attentive to homework completion. Dahl and Lochner (2005) found that an income increase of $1,000 was associated with an increase in mathematics test scores of 2.1% of a standard deviation and in reading test scores of 3.6% of a standard deviation ("Research on Closing the Achievement Gap," n.d.).

In a meta-analysis replicating White's (1982) study on socioeconomic status and academic achievement, Sirin (2005) examined how the relationship between socioeconomic status and academic achievement varies with the types of socioeconomic status, identified as family income, parent education, and family structure.

Despite conceptual differences in defining socioeconomic status, Duncan et al. (1972) identified three major indicators of socioeconomic status: (a) parental income, (b) parental occupation, and (c) parental education. Parental income provides necessary economic resources to the student whereas parental education (one of the most stable aspects of socioeconomic status) determines a student's academic success. Complementing the above tripartite factors (parental income, parental occupation, and parental education), several other indicators are also used to reflect socioeconomic status. Socioeconomic indices are often constructed to combine information about economic status of a household and the prestige and culture of a given socioeconomic stratum. Indices such as school socioeconomic status have been used to find the relationship between socioeconomic status and student achievement (Sirin, 2005). School socioeconomic status is measured on the basis of the proportion of students at each school who are eligible for free and reduced lunch. Family socioeconomic status helps to determine the kind of school and classroom environment. School location and minority status are found to moderate the relationship between socioeconomic status and academic achievement (Sirin, 2005).

Duncan and Magnuson (2005) examined whether socioeconomic status of families has an effect on school readiness of American preschoolers. The authors provided an overview that many Black and Hispanic students start their early careers with minimal resources which in turn increases the Black/white and Hispanic/white achievement gap. The authors also illustrated that the four key conditions, parent education (measured as parental human capital), family income, family structure and neighborhood conditions, are the key determinants of socioeconomic status of parents. Differences in these available resources lead to differences in kindergarten preparedness of students, and hence lead to achievement differences.

Lee and Bowen (2006) investigated the relationship between parental involvement, cultural capital, and achievement gap among elementary school children from third through fifth grade. The result of this study demonstrates that poverty and race/ethnicity consistently played a significant role in predicting children's academic achievement, and parental involvement has minimal role in explaining academic achievement of students. It was also evident from this study that cultural capital, social capital, human capital, and economic capital are often interrelated, and all these capitals vary across demographic groups. In the long run, variations in these capitals across diverse demographic groups lead to the disparity in academic achievement of the different groups.

Jordon and Levine's (2009) research focused on how socioeconomic variation is related to young children's mathematics learning ability. Though the roots of mathematics learning difficulties are related to fundamental weakness in number, number relationships, and number operations, this research illustrated that children from disadvantaged, low-income families perform poorly in mathematics compared to their counterparts from high-income families. A child's income status and associated early childhood development influences the level of mathematics knowledge. Mathematics readiness data generated from this study showed that low-income preschoolers who attend Head Start programs perform worse than their counterparts who attend preschools serving middle-income students. Many young children from low-income families receive less support for mathematics in their home environment than their middle- and high-income peers.

Ozturk and Singh's (2006) research explained the direct and indirect effects of socioeconomic status and previous mathematics achievement on high school advanced mathematics course taking. It was observed that parental involvement plays a critical role in students' achievement and advanced mathematics course taking. Students whose parents are adequately informed by the schools end up taking more advanced classes in mathematics. However, Starkey and Klein (2008) explained that instructional programs can prepare disadvantaged low socioeconomic status children for school mathematics and reduce socioeconomic status-related mathematics gap.

Siegel (2011) analyzed the impact of socioeconomic factors of parent education level and family income on the academic achievement of students of Hispanic and white ethnicities. The results illustrated a statistically significant gap in achievement between

Hispanic and white students. Further analysis showed no gap at higher socioeconomic levels and a widening discrepancy in scores with decreasing family income and parental education levels. Additional testing for the effects of school-wide variables found a small negative impact on student achievement for schools with high average parental education levels.

Tucker-Drob and Harden (2012) examined the impact of genetic influences on achievement. The genotype and phenotype (Gardner, 1982) interactions occur prior to children's entry into formal schooling. The authors hypothesized that one pathway through which socioeconomic status promotes genetic influences on early achievement is by facilitating the processes by which children select, evoke, and attend to learning experiences that are consistent with genetically influenced individual differences in their motivation to learn. This hypothesis was examined in a nationally representative sample of approximately 650 pairs of four-year-old identical and fraternal twins who were administered a measure of mathematics achievement and rated by their parents on a broad set of items assessing learning motivation. Results indicated a genetic link between learning motivation and mathematics achievement that varied positively with family socioeconomic status. Genetic differences in learning motivation contributed to mathematics achievement more strongly in more advantaged homes.

NBPTS Certification Ensures High Quality Mathematics Teachers

> There is growing evidence that students are most motivated when teachers are strong on all three legs of the instructional tripod: content knowledge, pedagogic skills, and relationship skills. Teachers differ a great deal in their effectiveness. The evidence is clear that some teachers produce much larger achievement gains than others do and that differences in teacher effectiveness tend to persist from year to year in the absence of effective professional development. (Ferguson, 2007, p. 50)

A large numbers of students, especially those who are poor or are members of minority groups, are taught by teachers who do not have strong backgrounds in the subjects they teach. For achieving high standards, students need teachers who know the subjects and know how to teach the subjects. Research suggests that NBCTs are highly qualified in their subject area (Bond, Smith, Baker, & Hattie, 2000; Ralph, 2003). The NBPTS is a nonprofit nonpartisan organization which was established in 1987. The five core propositions of the NBPTS (2013b) are:

1. Teachers are committed to students and their learning.
2. Teachers know the subjects they teach and how to teach those subjects to students.
3. Teachers are responsible for managing and monitoring student learning.
4. Teachers think systematically about their practice and learn from experience.
5. Teachers are members of learning communities. (n.p.)

Based on these five core propositions, rigorous standards for teaching mathematics and other subjects were specified.

Several school districts that encouraged their teachers to obtain NBPTS certification were successful in reducing achievement gap and improving student performance. A survey of NBPTS candidates found that 92% reported the process made them better teachers, and 89% said it equipped them to create stronger curricula and better evaluate student learning (Yankelovich, 2001). The National Board Certification process improves teachers' professional development by (a) enhancing reflection on teaching practice, (b) establishing a professional discourse among teachers, (c) raising the standards for teaching performance, and (d) facilitating collaboration (Park, Oliver, Johnson, Graham, & Oppong, 2007). Teachers report that National Board Certification is a "transformative experience" for them, and they often apply in the classroom what they learn from the certification process whether they achieve certification or not. The certification process itself improves teachers' ability to improve student learning (Vandevoort et al., 2004). Research studies showed that students of NBCTs outperform students of non-NBCTs on achievement tests, and the positive effect is even greater among minority students (Cavalluzzo, 2004; Clotfelter et al., 2007; Goldhaber & Anthony, 2007). In 2008, 42% of NBCTs were teaching in schools eligible for Title I funding and nearly 46% teach in schools where the free and reduced lunch percentage is more than 40%. The 2008, the National Council Research Report confirmed that National Board Certification has a positive impact on student achievement, teacher retention, and professional development. Students of NBCTs exhibit stronger writing abilities, comprehension and integration of complex classroom material, understanding of concepts, and abstract thinking than students of non-NBCTs (NBPTS, n.d.).

Lustick and Sykes (2006) investigated the NBCTs assessment process to identify the learning outcomes of the candidates. One hundred and twenty candidates certified for the Adolescent and Young Adult Science (AYA Science) were studied over a two-year period. If teacher learning is considered to be an important part of a highly effective teacher, this study also confirmed that Board certification provides the opportunity for teachers to learn about specific aspects of their work. Irrespective of the particular school setting and success in Board certification examination, teachers in this study demonstrated significant learning in the areas of scientific inquiry and assessment.

Sato, Chung, and Darling-Hammond (2008) examined how mathematics and science teachers' classroom practice in California was affected by the National Board Certification process. This study highlighted the fact that how teachers' visions of assessment practice changes with National Board Certification. When these teachers are compared with a noncertified cohort, it was observed that the assessment practices used by NBCTs were more successful in promoting students' learning compared to their non-NBCTs.

Vandevoort et al. (2004) compared the academic performance of students in the elementary classrooms of 35 NBCTs and their noncertified peers in 14 Arizona school districts. Four years of results from the Stanford Achievement Tests (SAT-9) in reading, mathematics, and language arts in grades 3 through 6 were analyzed. In the 48 comparisons (four grades, four years of data, three measures of academic performance), using gain scores adjusted for students' entering ability, the students in the classes of NBCTs surpassed students in the classrooms of noncertified teachers in almost three quarters of the comparisons.

Cavalluzzo's (2004) study correlated the relationship between student gains in mathematics in the ninth and tenth grades with NBCTs. The study found that National Board Certification is the most effective indicator of teacher quality other than subject area teacher and a teacher with a regular state certification. The result shows statistically significant evidence of their influence on student outcomes. These findings also suggest that school systems that wish to target pay increases to teachers of the highest quality can use National Board Certification for this purpose. This strategy may benefit students in the long term if National Board Certification has the desired effect of attracting better candidates into teaching. Moreover, to increase student outcomes in the nearer term, the challenge for school systems will be to implement professional development programs or strategies that change practices so more teachers will adopt methods used by those who have already achieved certification.

McColskey et al. (2005) conducted a two-phase study on teacher effectiveness and fifth grade student learning. The first phase of the results did not show any significant relationship between National Board Certification and student learning. There was no clear pattern of effects on student achievement based on NBCT status and no significant mean differences were found between fifth grade student taught by NBCTs and non-NBCTs on the mathematics or reading. However, the second phase of the study showed a significant difference in cognitive ability of students in reading who are taught by NBCTs. NBCTs are more organized in their lesson plan preparation compared to their non-NBCT cohorts.

Smith, Gordon, Colby, and Wang (2005) assessed the impact of National Board Certification on student achievement. The authors compared teachers who attempted but did not achieve National Board Certification with teachers who had National Board Certification. The overall findings from this study indicated that student learning ability and National Board Certification are highly correlated. NBPTS teachers increase deeper understanding within students compared to the non-NBCTs.

Goldhaber, Perry, and Anthony's (2004) study, based on a data set from North Carolina, assessed the relationship between NBCTs and elementary-level student achievement. Student-level value-added models were estimated and tested to determine whether the value added by NBCTs differs from that of unsuccessful NBCT candidates and non-applicant teachers. The results shows that NBCTs, based on student achievement gains, appeared to be more effective than their noncertified counterparts.

However, Sanders, Ashton, and Wright (2005) assessed student performance in two school districts on the North Carolina end-of-grade examination for fourth through eighth grade students in reading and mathematics. The findings of this study suggest that there is no significant effect on students' learning with NBCTs.

Harris and Sass (2009) examined the effectiveness of National Board Certification. Using a large data set of Florida teachers, this study demonstrated that NBCTs are more effective in increasing student test scores in reading compared to their non-NBCT counterparts.

Clotfelter et al. (2007) investigated the effect of National Board Certification and student achievement. An education production function was estimated to observe the students' achievement gains in reading and mathematics when they are taught by NBCTs compared to non-NBCTs. The result illustrated that students had more significant achievement gains in mathematics than reading when they are taught by experienced NBCTs. This study further highlighted the fact that teacher credentials have more positive effects on student test scores and achievement when compared to class size and socioeconomic status of the students.

School Characteristics and Academic Achievement

> Schools have always been able to provide opportunities, better or worse, based on zip code. The wealthiest schools around the country can provide resources that other urban and rural schools may not be able to provide. ….Suburban schools have had problems with parents using addresses where they do not live (parents, grandparents, etc.) so that their child does not get kicked out of the school and sent to the one in the community where they really live. That sort of dishonesty would not be happening if all schools were created equally. There has been a real disconnection between urban, rural and suburban school districts. (DeWitt, 2012, para.1. 2)

School characteristics are often defined in terms of school socioeconomic status, classroom size, and location of the school. There is a general perception that school characteristics or school quality is strongly related with academic performance of students. Fan and Chen (1998) examined the issue whether any differences exist in school achievement among rural, suburban, and urban school students in four major areas of school learning: reading, mathematics, science, and social studies. The urban, suburban, and rural schools of four geographic regions of the United States (the Northeast, Midwest, South, and West) were chosen (classifications of rural, suburban, and urban schools and of geographic regions were based on the 1980 census classification of the schools from which the students were sampled). Performance comparisons among rural, suburban, and urban students were made for the nationally representative samples of eighth, tenth, and twelfth graders in four areas of school learning: reading, mathematics, science, and social studies. Along with the area of school learning, performance comparison analyses for the four major ethnic groups (Whites, Blacks, Hispanics, and Asian Americans and Pacific Islanders) were conducted separately. A different set of performance analyses was also done for public and private school students. The results from each of these groups demonstrated that students from rural schools performed equally with their peers in metropolitan schools in mathematics, science, reading, and social studies.

Griffith (1996) used school-level data on parent perceptions and structural characteristics of 42 elementary schools to examine the relation of parental involvement and empowerment to student academic performance. The school characteristics included by Griffith (1996) consists of percentage of students in (a) racial and ethnic groups (Black, Asian American, Hispanics, and whites); (b) the free and reduced lunch program; and (c) enrolled in English as a second language. The result illustrated that positive relations of parental involvement to student test performance were largely unaffected by school characteristics or the socioeconomic, racial, and ethnic composition of the student population. School characteristics, socioeconomic status, and racial and ethnic composition play an insignificant role when parental involvement is high.

Many researchers claimed that school characteristics (urban vs. suburban schools) play a significant role in academic achievement of students. Capps et al. (2005) reported the experiences of three large urban school districts in New York that raised academic performance for their districts as a whole while also reducing racial differences in achievement. Educational challenges included (a) low achievement, (b) political conflict, (c) inexperienced teachers, (d) low expectations, and (e) lack of instructional coherence. The research involved case studies of these districts and comparisons with other districts that had not yet seen similar improvements. Researchers conducted site visits to each district, interviews with key district-level actors, focus groups, teachers, and principals, as well as document reviews. Results indicated that political and organizational stability over a prolonged period and consensus on educational reform strategies were necessary prerequisites to meaningful change. Districts faced systemic challenges above the individual school level. They lacked clarity regarding instructional standards and had a wide variety of educational strategies and instructional approaches. To achieve instructional coherence, districts adopted or developed their own uniform, relatively prescriptive reading and mathematics curricula for the elementary grades. The districts used data to guide instruction and decision making. Leaders in these districts invested substantial amounts of time, effort, and resources in changing district culture and creating a system-wide consensus for reform.

Konstantopoulos's (2006) study used three major national surveys of the 1970s, 1980s, and 1990s which provided information about student achievement, student background, and school characteristics. He examined the between-school variation in achievement and the importance of school characteristics in predicting student achievement and explaining variation in achievement over time. This research provided evidence about the importance of school factors in predicting student academic achievement over time. It is observed that students attending schools in the South had lower average achievement than students attending schools in other regions. In contrast, students in high socioeconomic status schools had higher average achievement than students in lower socioeconomic status schools. In addition, schools with high levels of student attendance, high proportions of graduates in colleges, and low dropout rates had higher average achievement than other schools.

Research and intervention in urban schools has centered on strategies to institute more ambitious learning standards and on improving the quality of curricula, pedagogy, and assessment. However, a serious barrier to urban school effectiveness and student achievement gains is measured by the amount of instructional time urban schools actually deliver to their students. Smith (2000) shared a series of instructional time analyses to illustrate how school management, social and cultural welfare programs, high-stakes testing, system policies, and a flawed notion of organizational efficiency combine to cripple enormous blocks of annual instructional time in a large urban district. Reduction in the number of days of instructional time lowers students' level of performance.

Many research studies established the correlation between school size and ethnic interpersonal dynamics. It is often observed that with larger school size, Black and

Hispanic students feel disconnected from school compared to their Asian American and white peers. Crosnoe, Johnson, and Elder (2004) examined the effect of school size on interpersonal process and how the effect varies across various ethnic groups. They used multilevel modeling techniques to a sample of 14,966 students in 84 schools from the National Longitudinal Study of Adolescent Health Results. It was observed that increasing school size was associated with decreasing student attachment to school and to teachers. Student attachment and teacher bonding diminished with increasing school size at a decreasing rate. However, these patterns did not differ substantially by ethnicity.

School quality is often determined by the amount of money schools spend on variety of school resources. A large number of studies try to evaluate the strength of the relationship between school quality and education attainment by using education production function. Fertig and Wright (2005) used data from 31 countries participating in PISA to estimate education production functions for reading literacy. This analysis suggested that class size has a significant correlation with student achievement level.

Researchers debate over various methods of instructional quality in schools and they differ in opinion whether small group instruction in schools helps in closing the achievement gap or not. Garrett and Hong (2012) investigated whether small group instruction in kindergarten widens or closes the achievement gap in mathematics between English language learners (ELL) students and non-ELL students. The authors examined the impacts of small group instruction on mathematics learning between ELL kindergartners and their non-ELL peers. If small group instruction brings more benefit to ELLs than it does to non-ELLs, then grouping may have the potential of helping ELL students enhance their mathematics learning. If the opposite is true, then grouping may leave ELL students further behind academically. However, even if small group instruction is beneficial to the ELLs, it may not lead to a substantial reduction in achievement gap if ELLs have less access to grouped instruction in comparison with their non-ELL peers. Conversely, if grouping practices occur at the detriment of ELL students, overuse of this practice could also exacerbate achievement disparities.

Dobbie and Fryer (2009) presented four pieces of evidence that high-quality schools or high-quality schools coupled with community investments generate the achievement gains. Harlem Children's Zone (HCZ) is one of the most ambitious social experiments in increasing the achievement of the poorest minority children. It combines community investments with reform minded charter schools. HCZ provided the first empirical test of the causal impact on educational outcomes with an eye toward informing the longstanding debate whether schools alone can eliminate the achievement gap or whether the issues that poor children bring to school are too much for educators alone to overcome.

Chapter 3. Methodology

Introduction

This study is utilizing a model from economics to explain the systematic relationship between student performance and (a) teacher quality, (b) socioeconomic status, (c) school characteristics, and (d) student demographics. This chapter begins with an overview of the purpose of the study, research questions, and research design proposed by the researcher. A part of this chapter focuses on the methods used in the literature of education production function, and the rest of the chapter focuses on sample size, methodology, and the rationale behind choosing such sample size and methodology.

Purpose of the Study

The purpose of this study is to use the concept of an education production function which will measure student performance (output) as a combination of inputs: (a) students' previous year's test score, (b) teacher quality (measured by National Board Certification), (c) socioeconomic status (measured by free and reduced lunch population), (d) school setting (urban, suburban), and (e) student demographics (measured by ethnicity and special needs student population).

Research Questions

1. Is there a relationship between student performance in mathematics and Nationally Board Certified teachers?

2. Is there a relationship between current year performance in mathematics and previous year's performance in mathematics for different cohorts in the same school and grade?

3. Is there a relationship between student performance in mathematics and socioeconomic status?

4. Is student performance in mathematics in suburban schools higher than urban schools?

5. Is there a relationship between student performance in mathematics and ethnicity?

6. Is there a relationship between student performance in mathematics and special needs student population?

Research Methods in the Literature of Education Production Function

The input-output analysis model used in the Coleman Report of 1966 (Coleman et al., 1966) stated the importance of relationship between school inputs and achievement. The report introduced a variety of statistical and technical issues which included statistical significance, analysis of covariance, production efficiency, multicollinearity,[2] residual variation, estimation bias, and simultaneous equations. Though policy relevance of input-output analysis led to rapid growth, it generated many different contradictions. Economists modified the input output analysis to "education production function" (Hanushek, 1979, p. 352). Education production function can only measure the maximum feasible output (student performance based on student test scores) from alternative combinations of inputs. It summarizes the technical relationship between inputs and outcomes. It also provides a standard against which practice can be evaluated on

[2] When the independent variables are correlated, in statistics, it is called the problem of multicollinearity. Multicollinearity increases the value of standard errors making some variables statistically insignificant while they should be otherwise significant.

productivity grounds (Monk, 1989). Unlike other technical studies, education production function informs us about the maximum output given the amount of existing resources. It provides the basis for efficiency. To summarize, education production function helps to improve educational productivity. Second, it is not possible to dismiss the existence of education production function on empirical grounds because of the estimation method. Third, it is difficult, if not impossible, to dismiss its existence on conceptual grounds. For these reasons, the education production function is well suited to serve as the conceptual base of a policy-oriented research program in education (Monk, 1989).

Ordinary least square method is normally used to analyze educational production function with single outcome. Production function estimation with test scores is more appropriate for earlier grades than later grades since the emphasis is on cognitive skills (reading or arithmetic) (Hanushek, 1979).

A large number of research studies have used education production function to analyze student performance or outcome. However, there is a wide variation in the variables chosen in the literature for analyzing student performance. Aaronson et al.'s (2007) study on education production focused only on teacher quality as a variable for measuring student performance. Marcotte (2007) examined instructional time as the vital component of the education production function whereas Coates (2003) used education production function to examine the correlation between instructional time teachers spend on each subject and student performance in the public elementary schools in Illinois. Gyimah-Brempong and Gyapong (1991) used data from school districts in Michigan to investigate whether socioeconomic status contributed significantly to the production of educational outcomes in ways that are independent of their effects on school resources.

Pritchett and Filmer (1999) used allocation of school resources as a variable to estimate student performance. Hanushek and Rivkin (2012) used value added by a teacher as an unique variable for examining student achievement gains. Houtenville and Conway (2008) estimated a value-added education production (including parental effort as an input) using data from the National Educational Longitudinal Study (NELS). Hanushek and Woessmann (2007) used education production function to measure whether the achievement of individual students is related to inputs which are directly controlled by policy makers (e.g., the characteristics of schools, teachers, curricula, and so forth) or by indirect inputs (which are not controlled by policy makers) such as families, friends, or learning capacities of the students. Hanushek and Woessmann's (2007) research confirms the fact that education is a cumulative process that affects students' current level of achievement from inputs applied sometime in the past.

Researchers have varied opinions about teacher effects on student achievement. The literature of education production function suggests that the effects of observed teacher characteristics on student achievement are negligible, while others consider teacher characteristics as one of the key component of student achievement (Greenwald et al., 1996; Hanushek, 1986). There are other groups of studies which have consistently documented that teachers differ substantially in their effectiveness, measured as between-classroom variation in student achievement (Hanushek, 1986; Nye et al., 2004; Rivkin et al., 2005). Konstantopoulos (2011) examined the continuing benefits of teacher efforts on student achievement in early elementary grades. The findings support that teachers significantly affect reading and mathematics achievement not only in the current or the following year, but in subsequent years as well. However, the results also show that teacher effects estimates in lower grades are smaller than estimates in later grades. Students who receive effective teachers in three consecutive grades (kindergarten through second grade) experience an increase in their achievement in third grade reading. These effects are considerable and comparable to achievement increases caused by cumulative effects of small classes in early grades.

Several researchers claim that smaller class size and high level of academic achievement are correlated with each other. Babcock and Betts' (2009) analysis answers the question whether reduced class sizes mainly boost achievement by helping teachers impart specific academic skills to students with low academic achievement or if they do so primarily by helping teachers engage poorly behaving students. The analysis used the grade 3 to 4 transition in the San Diego Unified School District as a source of exogenous variation in class size. Results indicate that student engagement, rather than the teaching of specific skills, is the dominant channel by which small classes influence disadvantaged students.

Research Design

Unlike previous research, this study uses a combination of variables, NBPTS certification (measure of teacher quality), socioeconomic status of students (percentage of free and reduced lunch population enrolled in the school in a particular year), student demographics (defined by ethnicity and special needs population), and school characteristics (defined by urban and suburban) as the major independent variables to estimate student outcome. As suggested by previous research, education production estimation varies from simple ordinary least squares (OLS) method to hierarchal linear model. This study will use cross-sectional regression analysis to capture how the variation in the independent variables affects the dependent variable over a period

Estimated model

$$Y_{it} = \alpha + \beta_1 TestS + \beta_2 SES + \beta_3 NBCT + \beta_4 SchoolC + \beta_5 AMI + \beta_6 API + \beta_7 HIS + \beta_8 BLK + \beta_9 WHT + \beta_{10} SPED + \mu$$

where Y_{it}, the dependent variable, is measured as average student test score in mathematics. The independent variables are: (a) NBCT representing Nationally Board Certified teachers in the district in year t; (b) $TestS$ representing previous year's average test score in mathematics; (b) *socioeconomic status* represents the percentage of free and reduced lunch population in the school; (c) *SchoolC*, dummy variable representing school setting based on the location of the school; (d) *AMI* represents the percentage of American Indian students in the school; (e) API represents the percentage of Asian and Pacific students in the school; (f) *HIS* represents the percentage of Hispanic students in the school; (g) *BLK* represents the percentage of Black students in the school; (h) *WHT* represents the percentage of white students in the school; (i) *SPED* represents the percentage of special needs student population; μ is the school specific error.[3]

Population and Sampling Procedure

The target population in this study was fifth grade students in Minnesota. The sample consisted of performance data for fifth grade and fourth grade students in 390 public schools of Minnesota. The school districts were selected based on (a) variety of socioeconomic status, and (b) availability of NBCTs.

[3] Individual's performance may be also be affected by school/classroom level factors as well as individual specific factors. For example, any changes in budgetary allocation of schools, or administrative changes in the school, normally considered as school level factors, can influence how students perform; whereas a change in students' personal backgrounds, such as new peers, changes in family structure, changes in parental skill levels, nutrition, and many such factors can also influence students' performances.

In this research, the study units consisted of fifth grade students in Minnesota as the main target population. Generally, fifth grade mathematics performances reflect the level of preparedness for middle schools. Fifth grade mathematics performance also represents an important predictor of academic achievement in the long run and on-time graduation completion. The collected sample consisted of fifth grade and fourth grade students in 390 public schools of Minnesota. The school districts selected represent a wider variety of socioeconomic status and availability of NBCTs.

This study explored the importance of teacher certification (NBCT) on students' mathematics performance.[4]From 14 certification areas of NBCTs, teachers with mathematics and early adolescence certification, generalists with middle childhood certification, and exceptional needs specialists were chosen as samples for this study. Surprisingly, there were only 24 mathematics and early adolescence certified teachers from all the school districts in Minnesota. However, the licenses of 14 of the teachers had expired prior to 2011, leaving only 10 teachers with existing NBCT certification valid in 2012, the chosen year of the study. Due to this small sample, the areas of NBCT certification were extended to include generalist middle childhood (8-12 years) and teachers with exceptional needs specialist (2-18 years). Based on information from the NBPTS website, which reports data at district level and not at school-level, 96 generalist middle childhood and exceptional needs specialist certified teachers were found across all school districts of Minnesota. To make the district-level data compatible with school-level, the NBCT variable was coded as a categorical variable with two levels as 0 or 1.

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[4]Due to unavailability of NBCT, data from the Minnesota Department of Education NBCT was compiled from the NBPTS website. However, records for school districts with no NBCT are not listed on NBPTS website.

School districts with NBCTs are coded as 1 and school districts without NBCTs are coded as 0.

Although considered in the initial sample, rural schools were finally dropped from the actual sample since data for NBCTs were available only for two rural schools. The inclusion of rural schools in the study would introduce sample inadequacy and non representative of the population.

Importance of the Chosen Variables

Promoting teacher quality is found to improve student achievement in the United States (Harris & Sass, 2009). Research is mostly conclusive that NBCTs result in higher student achievement scores than non-NBCTs (Cavalluzzo, 2004; Goldhaber & Anthony, 2007). Despite general disagreement on how the standard for certification should be determined, very few disagree that NBCTs are more qualified as compared to the teachers who are not Board certified. Research also shows that NBCTs, regardless of their ethnicity, are more successful with students of color in comparison with teachers who are not Board certified (Clotfelter et al., 2007; National Research Council, 2008).

Mathematics performance among various ethnic groups provides an overview of the achievement differences in Minnesota. Results from the Minnesota Department of Education (2012a) show that in 2010-2011, 50.4% of all students who took the MCAIII math test in fifth grade were proficient. When breaking it down by ethnicity and socioeconomic status, 56.4% of white students tested proficient whereas only 8.5% of Black students and 7.9% of American Indian students were proficient. A larger percentage of Asian and Hispanic students (68.2% and 36.4%, respectively) were also found proficient. Interestingly, only 27.3% of students utilizing free and reduced lunch were tested proficient[5]. Though these findings are sporadic and small sample-based, the use of these variables is justified in the existing literature.

Other related variables found to influence students' mathematics performance are socioeconomic status and different school specific factors, such as budgetary allocations, classroom sizes, etc. Researchers have concluded that socioeconomic status is an important factor for determining student performance (Barton, 2003; Carey, 2002; Duncan & Magnuson, 2005; Evans, 2004; Reardon, 2011; Sirin, 2005). Other studies established school factors as important causes of achievement gap (Griffith, 1996; Hanushek & Woessmann, 2007; Konstantopoulos, 2006; Smith, 2000). However, due to unavailability of consistent data at school level, the school specific factors could not be considered in this sample.

This study attempts to find factors affecting the mathematics performance of students. For educational policymakers and school districts, findings from this study are particularly useful for resource allocation. Besides identifying important factors, this study also provides quantitative estimations of the magnitude or level of influence of the factors that influence students' performance in mathematics or achievement gap in mathematics.

[5] Free and reduced lunch data based on ethnicity was not available for the selected population.

Chapter 4. Data Analysis and Results

Research Questions

The following research question and sub questions provided the basis for data analysis and the rationale for choosing the quantitative strand of analysis:

What optimal combination of inputs (measured by NBCTs, socioeconomic status defined by free and reduced lunch population, student demographics defined by special needs population and ethnicity, and school setting) is required to produce the maximum amount of output (measured by students' test scores in mathematics)?

1. Is there a relationship between student performance in mathematics and Nationally Board Certified teachers?
2. Is there a relationship between current year performance in mathematics and previous year's performance in mathematics for different cohorts in the same school and grade?
3. Is there a relationship between student performance in mathematics and socioeconomic status?
4. Is student performance in mathematics in suburban schools higher than urban schools?
5. Is there a relationship between student performance in mathematics and ethnicity?
6. Is there a relationship between student performance in mathematics and special needs student population?

Quantitative Analysis

This study used quantitative data analysis of existing MCA student data from the Minnesota Department of Education and the NBPTS. Fifth grade and fourth grade student data from 390 schools in Minnesota were used in this study. The following multivariate regression equation provides the general framework used to address the research questions:

$$Y_{it} = \alpha + \beta_1 TestS + \beta_2 SES + \beta_3 NBCT + \beta_4 SchoolC + \beta_5 AMI + \beta_6 API + \beta_7 HIS + \beta_8 BLK + \beta_9 WHT + \beta_{10} SPED + \mu$$

See Table 1 for information regarding these variables. In the preceding equation μ is the residual term that captures any effects unaccounted by the suggested explanatory variables.

Table 1

Summary of Variables

Variable Abbreviation	Variable Type (Level of Measurement)	Construct	Operational Definition	Data Source
Y_{it}	Dependent Variable (Ratio)	Current mathematics performance	2012 average school-level mathematics MCA test scores for fifth grade students	Minnesota Department of Education
TestS	Independent Variable (Ratio)	Previous year's mathematics performance	2011 average school-level mathematics MCA test scores for fourth grade students	Minnesota Department of Education
Socioeconomic status	Independent Variable (Ratio)	Socio-economic status	Percentage of fourth grade students in the school who qualify for free lunch	Minnesota Department of Education

Table 1, continued.

Variable Abbreviation	Variable Type (Level of Measurement)	Construct	Operational Definition	Data Source
NBCT	Independent Variable (Nominal)	Nationally Board Certified Teachers	Presence of Nationally Board Certified teachers in the school coded 1 if NBCTs are present in school district and 0 if they are not present in the school district	National Board of Professional Teachers Organization
SchoolC	Independent Variable (Nominal)	School setting	Geographic location of the schools; (coded 0 = urban, 1 = suburban)	Minnesota Department of Education
AMI	Independent Variable (Ratio)	Ethnicity: American Indian	Percentage of fourth grade students in the school who are classified as American Indian	Minnesota Department of Education
API	Independent Variable (Ratio)	Ethnicity: Asian and Alaskan Pacific	Percentage of fourth grade students in the school who are classified as Asian and Alaskan Pacific	Minnesota Department of Education
HIS	Independent Variable (Ratio)	Ethnicity: Hispanic	Percentage of fourth grade students in the school who are classified as Hispanic	Minnesota Department of Education
BLK	Independent Variable (Ratio)	Ethnicity: Black	Percentage of fourth grade students in the school who are classified as Black	Minnesota Department of Education
WHT	Independent Variable (Ratio)	Ethnicity: white	Percentage of fourth grade students in the school who are classified as white	Minnesota Department of Education
SPED	Independent Variable (Ratio)	Special needs population	Percentage of fourth grade students who are classified as special needs students[6]	Minnesota Department of Education

[6] This study used a cohort model to observe the achievement level of students. Hence, this study has used prior achievement level of students as an indicator of current success. Fourth grade data for student demographics are used assuming that the same group of cohort is promoted to fifth grade and there is no mobility of students within cohorts (inter group). Despite some minor differences in number of students moving from fourth grade to fifth grade cohort, such variability is found to be insignificant for cohorts in 2011-2012. Hence using fourth grade student demographic data keeps the sample consistent across two time periods in this study.

Note. This study is measuring school level achievement and not at individual level.

Statistical software SPSS was used for data analysis in this study. The descriptive statistics of the variables are presented in Table 2 and Table 3.

Table 2

Number of Schools and Average Score

Variable	Number of Schools	Mean	Std. Dev.	Min	Max
Average score 2012	390	551.01	6.79	518.7	569.2
Average score 2011	390	417.52	127.38	0	480.2

Table 3

Student Demographics[7]

Variable	Number of Schools	Mean	Std. Dev.	Min	Max
SES	371	42%	26%	0	100%
SPED	371	16%	9%	2%	100%
AMI	385	2%	6%	0	95%
API	385	10%	11%	0	73%
HIS	385	10%	13%	0	100%
BLK	385	16%	17%	0	100%
WHT	385	62%	28%	0	100%

[7] *Note*. Minnesota Department of Education does not report any data if the observation of a cell size is less than ten. Information on SES and SPED is not available for all 390 schools. Similarly, ethnicity information is not available for all schools. The Minnesota Department of Education does not report any data if the cell size or the number of observation is less than 10. In this case, SES and SPED information is available for 371 schools and ethnicity information is available for 385 schools.

Table 2 shows that in year 2012, fifth grade students in this sample showed an average score of 551, and in 2011, fourth grade students scored with an average test score of 418. Standard deviation (how far the observed score of an individual fifth grade student in a specific school deviates from the mean score of the overall sample) for average score of fifth grade students in year 2012 is 6.79 and 127.3 for 2011. Fourth grade students had higher standard deviations than fifth grade with average score ranges from 0 (minimum) to 480.2 (maximum). Since in case of fourth grade there are several observations with zero averagescore 2011 and also several cell values were missing, hence the minimum average score dropped down to zero[8].

Table 3 reports the student demographic information. From an overall sample of 371 schools in Minnesota, percentage of fourth grade students in SPED and low SES shows wide variations; some schools have no students while some have 100% of their students in these categories. Similarly, from an overall sample of 385 schools, on an average, fifth grade schools in Minnesota have 16% students in SPED category, and 42% in low SES category. When AMI, API, HIS, BLK, and WHT are considered, fifth grade schools student population range between 0-95%, 0-73%, 0-100%, 0-100%, and 0-100%, respectively, for each category. On average, fifth grade schools selected in this sample have 2% students as AMI, 10% API, 10% HIS, 16% BLK, and 62% WHT.

Quantitative Analysis and Regression Results

Multiple regression analysis was conducted to predict average school performance of fifth grade students. The impact of previous year’s test score of students, socioeconomic status, student demographics (measured by special needs population, five

[8] *Note*. The Minnesota Department of Education does not report any data if the cell size is less than ten.

different ethnic categories), National Board Certification of teachers, and school setting (defined by urban and suburban)[9] are used as the explanatory variables to assess fifth grade students' mathematics performance in the MCA test in year 2012.

Econometric model.

$$Y_{it} = \alpha + \beta_1 TestS + \beta_2 SES + \beta_3 NBCT + \beta_4 SchoolC + \beta_5 AMI + \beta_6 API + \beta_7 HIS + \beta_8 BLK + \beta_9 WHT + \beta_{10} SPED + \mu$$

Students' average test score (averagescore 2012) was used as the dependent variable. The explanatory variables were previous year's students' performance in mathematics, socioeconomic status, and student demographics (measured by percentage of special needs population, and percentage of five individual ethnic categories, National Board Certification of teachers, and school setting for predicting students' mathematics performance.

The linear combination of explanatory variables is significantly related to fifth grade students' average (mathematics) test score, $\underline{F}$ (10, 359) = 101.02, $\underline{p} < .001$. The multiple correlation-coefficient (R= .91) and the explained variance ($\underline{R}^2$ =0.74, adjusted $\underline{R}^2$ = .73) indicate that approximately 73% of the variance of fifth grade students' mathematics performance (average test score) can be accounted for by the explanatory variables, indicating a good overall model fit.

Results from the Econometric Model

The effect of fourth grade averagescore 2011 is statistically significant (β = .09, p < .001). The regression coefficient shows that a rise in fourth grade averagescore 2011

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[9] *Note*. Rural schools are not included in this study due to inadequate availability of the required information needed in this study.

increases fifth grade averagescore 2012 by .005 points (b = .005, t (359) = 2.88). With a positive relationship between students' current year performance and past year performance, one infers that higher performance level of students in past year indicates a higher probability of a higher performance in current year.

Similarly, effect of low SES and SPED was found to be statistically significant. SES (β = -.43, $p < .001$) is inversely related with averagescore 2012 indicating an inverse relationship between students' performance in mathematics and low SES population with a standardized coefficient of 10.86 (b = -10.86 t(359) = -7.88).

SPED (β = -.22, $p < .001$) also shows inverse relationship with averagescore 2012, implying a significant reduction in special needs population averagescore 2012 (b = -.15.63, t(359) = -7.42) by 15 points.

However, the individual student demographic variables, measured by five ethnic categories (two of the ethnic categories being American Indian and Black), were significantly related to averagescore 2012. AMI (β = -.091, $p < .05$) is significantly related with averagescore 2012, with a coefficient value (b = -9.26 t(359) = -2.01). This implies that there is a significant reduction in averagescore 2012 of AMI student population by 9 points. Similarly, BLK (β = -.225, $p < .05$) is significantly negative with averagescore 2012. This implies that there is a significant reduction in averagescore 2012 of Black student population by 8 points (b = -8.67, t (359) = -2.29). The other three ethnic groups, API (β = -.012, $p < .846$), HIS (β = -.125, $p < .087$), and WHT (β = .017, $p < .910$), do not show any individually statistical significance in predicting averagescore 2012. Similarly, SCHOOLC (β = .063, $p < .066$) is not statistically significant in predicting averagescore 2012. However, NBCT (β = .069, $p < .021$) is statistically significant in predicting averagescore 2012[10]. This implies that presence of NBCTs within a school system shows significant improvement in performance level.

Table 4

Econometric Model Results

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	b	Std. Error	β		
averagescore 2011	.005	.002	.090	2.888	.000
SES	-10.867	1.378	-.433	-7.888	.000
SPED	-15.637	2.105	-.220	-7.429	.000
AMI	-9.260	4.628	-.091	-2.001	.046
API	-.754	3.888	-.012	-.194	.846
HIS	-6.660	3.842	-.125	-1.718	.087
BLK	-8.676	3.787	-.225	-2.291	.023
WHT	.404	3.583	.017	.113	.910
SCHOOLC	.926	.501	.063	1.847	.066
NBCT	.978	.421	.069	2.327	.021

[10] The results of the variables, which are significant at 5 %, are only considered to be statistically significant in this study.

Graphical Representations

Figure 1 represents fifth grade students' MCA test score data from selected urban and suburban school districts of Minnesota.[11]

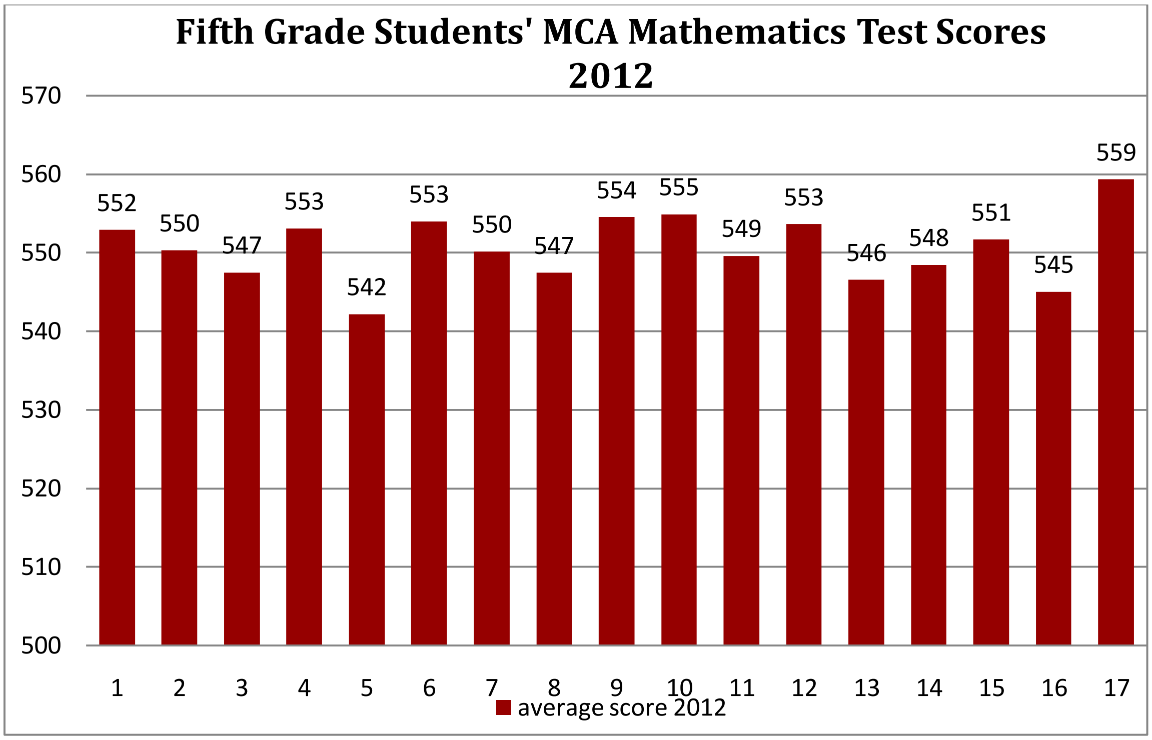

Figure 1. Fifth grade students' mathematics test scores in Minnesota Comprehensive Assessment (MCA) 2012.

Figure 1 describes the level of fifth grade students' achievement in mathematics. Average mathematics test scores in MCA 2012 test was used to denote the achievement level. From the sample of school districts chosen for graphical analysis, school district 5 shows

[11] Although the regression analysis considered a sample size of 390 individual schools, the above graphs showed a consolidated sample of 17 measured at school district level.
Note. The graphs have different origin points. For Figure 1, the origin starts from 500 since MCA average test scores of fifth grade is measured at 500 levels. Similarly, Figure-2 starts from 400 as MCA average test score of fourth grade is measured at 400 levels. Figure 3 and Figure 4 have different origins of measurement since these figures represent student demographics in percentages.

the lowest average test scores of 542 in mathematics in year 2012, and school district 17 shows the highest average students' test scores of 559 in year 2012. The graph shows school district 16 has average students' test scores of 545 and school district 13 and school district 14 have average students' test scores of 546 points and 547 points, respectively. School district 9 and school district 10 are close to each other with average students' test scores of 554 and 555 points, respectively.

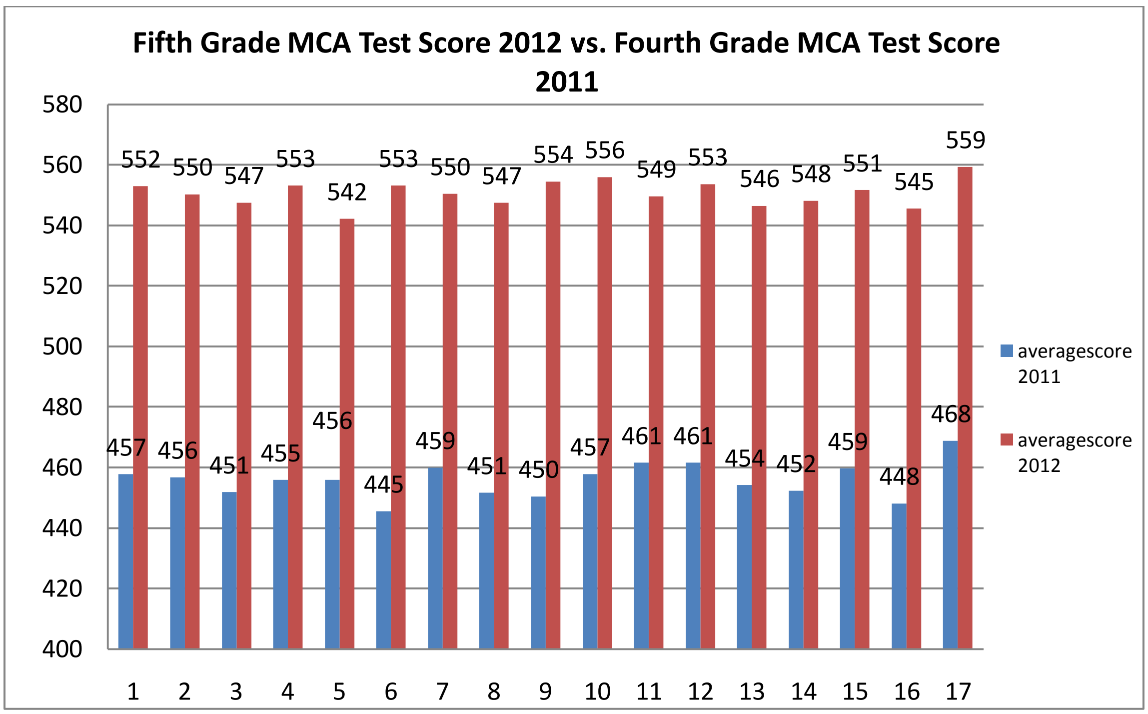

Figure 2. Fifth and fourth grade students' mathematics proficiency in MCA 2102 vs. 2011.

Figure 2 contrasts mathematics achievement of fifth grade students in MCA 2012 to fourth grade students in MCA 2011 test. School districts 5 and 8 have the lowest average score in both years 2011 and 2012. The graphical representation shows that in general, there is a positive correlation between MCA mathematics test scores of 2012 and MCA mathematics test scores of 2011. School districts with a higher level of mathematics test score in 2011 also had a higher test score in 2012.

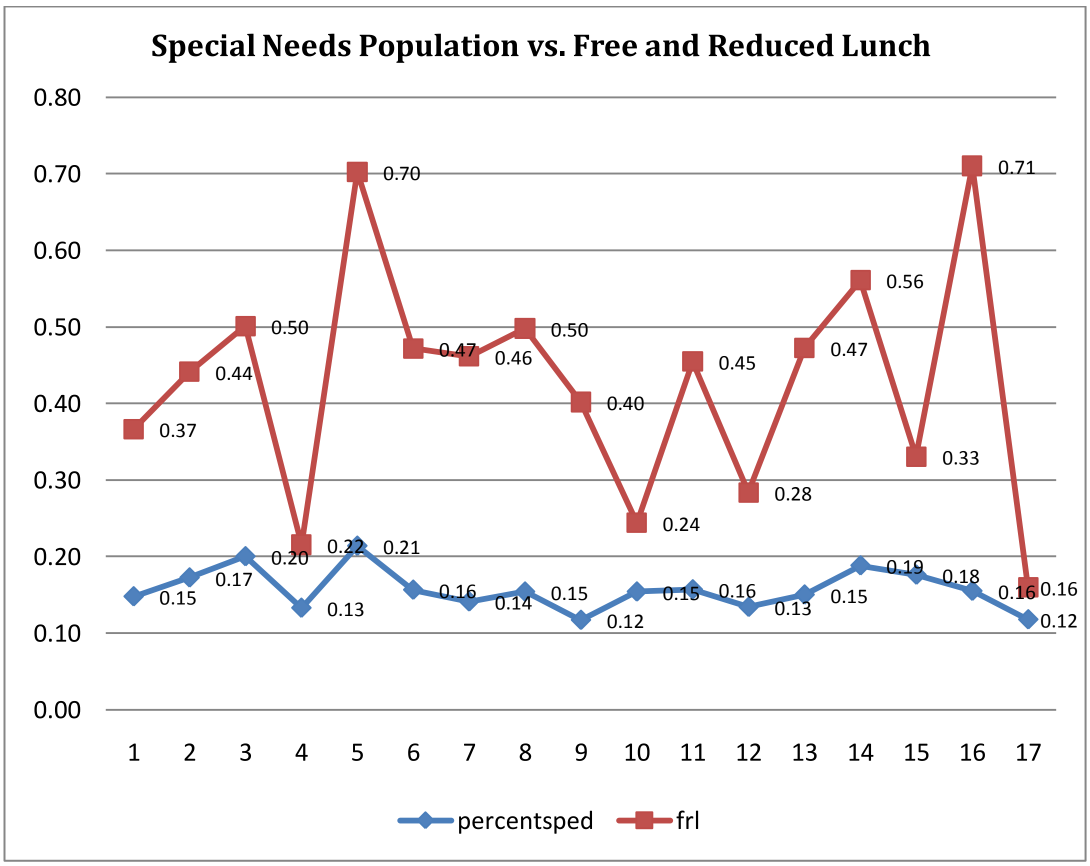

Figure 3. Percentage of fourth grade special needs students and students from lower socioeconomic status in year 2011.

Figure 3 illustrates percentage of free and reduced lunch population and special needs population in selected school districts of Minnesota. The 17 school districts in Minnesota have a higher percentage of free and reduced lunch population compared to special needs population. However, in school district 17, percentages of special needs population and free and reduced lunch population are close to each other. Twelve percent of the students in school district 17 are categorized as free and reduced lunch population, whereas 16% of the students are in the special needs category. School district 5 and school district 16 have the highest percentage of free and reduced lunch population with 21% special needs population in school district 5 and 16% special needs population in school district 16. From Figure 1 (MCA mathematics averagescore 2012), it is also observed that these districts have the lowest average test score of students. This indicates existence of an inverse relationship between students' average test score in mathematics and free and reduced lunch population. Similarly, an inverse relationship also exists between students' average score in mathematics and special needs population.

Figure 4 demonstrates fourth grade students' percentage of two ethnic groups (American Indian, Black) in year 2011.These two ethnic groups were chosen based on the regression results. From the regression results it is observed that average student test scores in mathematics were significantly lower amongst these two ethnic groups. Students who belong to these ethnic groups have lower levels of achievement compared to other ethnic groups.

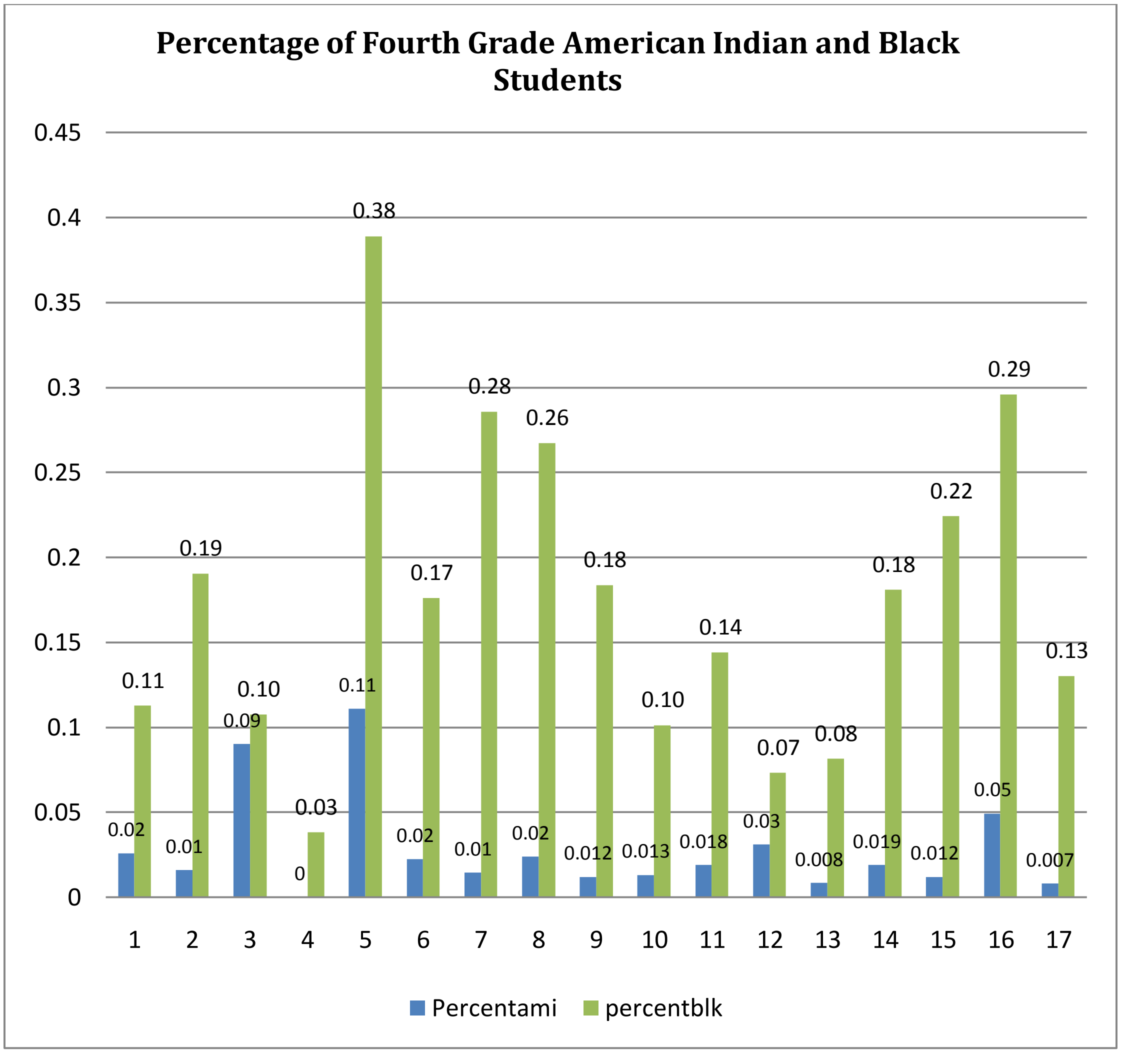

Figure 4. Fourth grade students' percentage of two ethnic groups in year 2011.

Conclusion

The purpose of this chapter was to analyze, explain, and explore the relationship between students' mathematics performance in the MCA test and student demographics, school setting (urban vs suburban), and teacher quality.

As originally predicted in the hypothesis, the results in this study show that students' previous year's performance in mathematics is a strong predictor for current year's average scores in mathematics and is significantly related with previous year's performance in mathematics. In other words, a higher level of performance in a previous year results in a higher level of performance in the current year. The hypotheses in this study also predicted an inverse relation between socioeconomic status, special needs population and students from non-white ethnic categories (especially, American Indian, Black and Hispanic) and students' mathematics performance.

From the regression analysis, it is observed that students' average score in the current year is significantly related with socioeconomic status, special needs, American Indian, and Black student population. An inverse relationship exists between averagescore 2012 and this student demographic group. However, this study did not find any significant relationship between Hispanic students and averagescore 2012.

However, this study is limited due to exclusion of ethnicity wise free and reduced lunch data. This information was not accessible from the Minnesota Department of Education. Hence drawing a comprehensive inference combining ethnicity and free and reduced lunch together remained out of the scope of this study.

Chapter 5. Summary and Discussions of Implications

Introduction

The final chapter of this study will include four major sections: (a) a review of the design of this study, (b) findings and discussion, (c) limitations of the study, and (d) discussion of future research prospects and conclusion.

Revisiting the Design of the Study

Often research in education uses a correlational study implementing a quantitative strand of analysis. Qualitative research methods and mixed method models are also commonly found in educational research. A qualitative research method is used to explore issues, understand phenomena, and answer questions by analyzing and making sense of unstructured data. In other words, qualitative research is a generic term for investigative methodologies described as ethnographic, naturalistic, anthropological, field, or participant observer research. Qualitative research explores phenomena in a natural setting where the event takes place. Detailed data are gathered through open-ended responses comprising direct quotations (Jacob, 1988). Such an approach differs from a quantitative study, which attempts to gather data by survey or questionnaire forms to provide numerical information about relations, comparisons, and predictions. For unbiased sampling, investigator maintains a neutral separation the investigation (Key, 1997; Smith, 1983). "A mixed methods research design is a procedure for collecting, analyzing, and mixing both quantitative and qualitative research methods in a single study to understand a research problem" (Fischler School of Education, n.d., p. 3). Given the purpose of the study, quantitative research methods are the appropriate technique for this study.

This study intended to find significant relationships and to estimate the impact of factors that influence students' mathematics performance. From this perspective, a quantitative study was an appropriate selection. From various quantitative methods, this research focused on a correlational study in general and linear regression in specific areas.

However, with a correlational analysis, one can only find pair-wise relationship between two variables and not the overall relationship involving multiple variables. Correlation makes no a priori assumption as to whether one variable is dependent on the other and is not concerned with the direction of relationship between variables; instead, it gives an estimate of the degree of association between the variables. Multiple linear regression attempts to model the relationship between two or more explanatory variables and a response variable by fitting a linear straight line to observed data. Every value of the explanatory variable is associated with a value of the dependent variable[12]. Advantages of using multivariate linear regression model include estimating precise impact of each exploratory variable on the dependent variable and include a wide range and types of variables in the analytical framework, providing a more general understanding of the phenomenon. However, multiple regression models have limitations in predicting non-linear relationships.

This study used multiple regression analysis to examine the variables which affect student performance in mathematics, assuming that a linear relationship exists between the dependent variables and independent variables. The MCA test scores in mathematics

[12] *Note*. Multiple regression model predicts a relationship between dependent variable and independent variable. It does not forecast or state the actual relationship. It is a predictive model.

(Minnesota Department of Education, 2012b) are used to measure student performance. The explanatory variables chosen for measuring the performance are (a) students' previous year's test score, (b) socioeconomic status of students measured by free and reduced lunch population, (c) student demographics measured by ethnic background of students and special needs population, and (d) teacher quality measured by National Board Certification.

Findings and Discussion

Siegel (2011) shows influence of socioeconomic factors on students' academic performance. In this study, student demographics were classified in terms of ethnicity and special needs population, along with socioeconomic status. The results from this study show that student socioeconomic status and academic performance in mathematics are inversely correlated. In the year 2012, free and reduced lunch population in schools of Minnesota has lower performance rate in MCAII. Unlike Siegel's 2011 study, this study finds a significant gap in special needs students' mathematics performance.

Lee and Bowen (2006) investigated the relationship between parental involvement, cultural capital, and achievement gap among elementary school children from third through fifth grade. Their results demonstrate that poverty and race/ethnicity consistently played a significant role in predicting students' academic achievement. This study conforms to their findings. In addition to a significant gap among free and reduced lunch students' performance, this study finds a significant gap among students from different ethnic backgrounds[13] with fifth grade American Indian students and Black

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[13] *Note*. However, due to unavailability of school level data combining poverty as well as race/ethnicity, it was not possible in this study to measure students' performance on this variable.

students performing poorly in MCAII mathematics tests. An inverse relationship between student performance in MCAII mathematics and Hispanic student population as found in this study, is not statistically significant. Similarly, no statistically significant relationship exists between white student population and their performance in MCAII mathematics.

The other explanatory variables used in this study are students' previous year's test score in mathematics, school setting, and teacher quality measured by NBCT certification. Students' previous year's test performance shows a statistically significant relationship with student current year performance. Students who have a higher score in 2011 MCAII mathematics also had a higher score in 2012 MCAII mathematics, a reconfirmation to Isenberg and Hock's (2010) study.

"Schools have always been able to provide opportunities, better or worse, based on zip code. The wealthiest schools around the country can provide resources that other urban and rural schools may not be able to provide" (DeWitt, 2012, para.1.2). A real disconnection exists between school districts. Fan and Chen (1998) examined whether any differences exist in school achievement among rural, suburban, and urban school students in four major areas of school learning: (a) reading, (b) mathematics, (c) science, and (d) social studies. The results from their study show that students in rural schools have performed equally well with the students in suburban schools. However, the current study considers only urban and suburban schools of Minnesota under school setting, as rural schools dropped out from the sample due to unavailability of consistent data for all the explanatory variables for the rural schools. Interestingly, like Fan and Chen (1998), the variable school setting does not show any statistical significance on student performance in mathematics.

Implications of the Results

To discuss the implications of this study in K-12 education, it may be useful to draw reference from Hanushek's (1979) research on education production function. Using the concept of a linear education production function, this study shows how different factors (as inputs) might influence student academic performance (as output). Research in education mostly investigated student academic performance in terms of a single input variable. However, the literature in economics of education based on education production functions measures how a combination of different inputs or factors[14] may influence student academic performance as output. Drawing from existing literature on student performance in mathematics and their achievement gap, this study identified some of the important factors that influence academic performance and explained reasons behind academic performance gap. The results of this study clearly show that students' academic performance measured by students' average test scores on MCAII is crucially dependent on student previous year's test score, socioeconomic status, student demographics, and teacher quality.

This study imparts important implications for K-12 educational policy making and identifies specific areas for effective resource allocation. As most studies concur that academic achievement is dependent on teacher quality, this study implies that greater importance given to teachers' certification would improve students' scores. Although there is no unanimity in deciding best standards for teacher quality, this study implicates that the presence of NBCTs is successful in improving academic achievement of

[14] *Note*. Instead of using individual student as the study unit, this study has used a group of students as the study unit.

students. Given the extremely small number of nationally certified teachers of mathematics in Minnesota, it becomes difficult to draw conclusions that achievement gap in mathematics in K-12 could be reduced solely by NBCTs. However, with a considerable number of NBCTs in K-5 who are certified as generalists in early childhood and middle childhood, this study finds their important influence on reducing performance gap. These teachers, as this study suggests, could surely bring in a positive change to the system. There is a need to increase the number of NBCTs in the areas of early adolescent mathematics and adolescent and young adulthood mathematics. School districts could allocate greater resources in developing more certified teachers in these areas.

A major implication of this research is in highlighting that special needs students, free and reduced lunch students, American Indian, and Black students have performed poorly in MCA mathematics tests. Since regression models do not show causality (they only indicate significant factors, which try to establish a relationship to the output variable), this regression-based study emphasizes that these student groups needs special attention for improving their academic performance and reducing the performance gap. School districts can design different remedial programs or direct intervention plans with this group of students or any other strategic plans involving educators, policy makers, and nonprofit organizations that benefit the above group.

Limitations

This study was based on aggregate fourth and fifth grade data of Minnesota schools for the years 2011 and 2012. Given the time frame, this study relied on secondary data sources from the Minnesota Department of Education. Based on existing literature, multiple regression analysis was done to examine the possible factors behind the student achievement gap in mathematics in Minnesota. This study attempted to identify the factors behind the student achievement gap in mathematics. However, this study had limitations in predicting all the reasons behind individual student achievement gaps. It would have been ideal to use individual student level data and analyze the data over a period of time. Also, instead of using students' average test score as a measure of performance, this study could have measured student growth in test score over a period of time to examine the achievement gap. Secondly, a multilevel model for analyzing the student achievement gap is generally used for analyzing student data. Existing studies on student achievement show that there is a wide variety of individual student characteristics which are related to student outcomes. These are not only limited to demographic characteristics (such as ethnicity), but also to (a) gender; (b) family characteristics, socioeconomic status, and family structure; and (c) academic background, such as prior achievement and retention. These characteristics have been shown to relate to such student outcomes, achievement (test scores), and dropout rates (Rumberger & Palardy, 2004). Though this study has considered socioeconomic status and demographic characteristics such as ethnicity and special needs population influencing student outcomes, due to the unavailability of data on prior achievement of all students and retention, it was not possible to include all these variables in this study. Although extant research highlighted the role of English language learners (ELL) students and their academic performance (Garrett & Hong, 2012), due to limited data availability on ELL, the variable was excluded from this study. For same reason, other important variables, such as school resource variables (both material and financial), had to be dropped from this study. Instead, school setting defined by the location of school was included as an alternative to represent school characteristics.

Value-added models measure teachers' contributions to student learning and are increasingly employed in educational reform efforts. Research has shown that value-added models provide better measures for teacher effectiveness (Isenberg & Hock, 2010). Using data from 35 seventh-grade teachers with a sample covering 2,026 students across seven schools, Ruzek, Domina, Conley, Duncan, and Karabenick (2014) employed the value-added method to measure teachers' contributions to students' motivational orientations and their mathematics performance. Teacher contributions are also associated with gains in students' seventh-grade mathematics achievement. However, this study used NBCT certification as a measure for teacher quality or teacher effectiveness. The results are similar to the value-added model in predicting the role of teacher quality to increase student outcomes.

What stands out from this research is that multilevel models are better suited to conduct research on student achievement. The primary choice of models depends on the research questions and on available data. Two key aspects of the data are relevant in selecting models: (a) whether the data represent measures at a single point in time (cross-sectional) or multiple points in time (longitudinal); and (b) whether the outcome measures are continuously distributed (e.g., standard test scores) or based on percentages such as proficiency scores. In this study, a cross-sectional sample was used while the outcome consisted of a continuous variable, student average test scores.

Conclusion

This research provides opportunities for future research. Longitudinal data for measuring student's performance over an extended period could be used to extend this model. A cohort model could be used to observe and analyze the performance of the same group of cohort over a period of 10 years to measure their performance from elementary through high school. This study could also be extended as a mixed method research where one could use quantitative methods as well as qualitative methods to analyze student performance. Instead of using multiple regression analyses only, this study could be extended to a multilevel model where school characteristics and school resources are both included as variables for measuring student outcomes. Similarly, as a measure of teacher quality, instead of using NBCT certification, teacher's area of specialization, teacher's professional development, and number of years of teaching experience could be used as variables for measuring student performance. In addition to student socioeconomic status and student demographics measured by ethnicity and special needs population, it is important to include ELL learners as a part of student demographics. It is also noteworthy to examine the effect of gender on student performance.

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