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An Analysis of Fifth-Grade Teachers' Mathematical Inputs on Eighth-Grade Students' Mathematical Outputs

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LOYOLA MARYMOUNT UNIVERSITY

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by

Neeraj Satyal

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An Analysis of Fifth-Grade Teachers' Mathematical Inputs on

Eighth-Grade Students' Mathematical Outputs

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ABSTRACT

An Analysis of Fifth-Grade Teachers' Mathematical Inputs on

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The purpose of this study was to explore and analyze which fifth-grade teacher inputs were the most important predictors of future outcomes of eighth-grade math students. This quantitative study looked at mathematical achievement through the lens of an education production function. The three inputs that were analyzed were fifth-grade teachers' background; perception of professional development; and instructional practices and the relationship of those practices to achievement in eighth-grade math. In order to find the relationship between the above variables and student achievement, descriptive statistics, multiple correlations, and multi-variable regression analysis were conducted to examine which predictors had a stronger relationship between eighth-grade math outcomes than others. Taken as a whole, fifth-grade teacher math inputs in this study seemed to explain a small part of the variance regarding eighth-grade math achievement. As a whole, the more frequently students wrote and spoke about math in fifth grade as well as used math tools effectively, the better the outcome in eighth grade.

CHAPTER ONE

INTRODUCTION

Background of the Problem

The United States economy is in a place of transition. Since the "great recession" of the late 2000s, which featured high unemployment rates and slow economic growth, a large contradiction has arisen: a substantial number of jobs that require knowledge of science, technology, engineering, and math (STEM) have gone unfulfilled. In 2012, according to the United States Department of Labor's Bureau of Labor Statistics, nearly one and a half million STEM-related jobs were available in an American economy that had recently experienced high levels of unemployment (Rothwell, 2013). The reason most cited is the lack of supply of skilled labor in STEM fields. While some challenge this does not actually exist, a vast body of research argues otherwise (Holzer, 2012; Rothwell & Ruiz, 2013). This shortage is largely seen as a bi-product of a K-16 American education system not producing enough students with effective math skills as well as interest in STEM fields post high school graduation (Thomasian, 2011). In short, when compared to the rest of the world, a majority of American students lack access to a high-quality math education (Atweh, Graven, Secada, & Valero, 2011; Smith, 2001).

On the most recent National Assessment of Educational Progress (NAEP) test, the United States ranked 22nd among industrialized countries in its math scores (Graham & Provost, 2012). Further, in the 2014 Programme for International Student Assessment (PISA), Americans ranked 26th in the world. This prompted United States Secretary of Education Arne Duncan to label the performance "a picture of educational stagnation" (Simon, 2013). Some have estimated that if trends stay constant, the financial impact that inadequate outcomes in math education may have on the U.S. economy over the next 80 years would roughly be $75 trillion dollars (Hanushek & Rivkin, 2007). The trends have been so discouraging that the federal government has chosen to intervene. This intervention has two major components: an emphasis on STEM education and a realignment of state educational standards based upon the Common Core Initiative pushed by the National Governors Association and the Council of Chief State School Officers (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010).

In regards to the first piece of that intervention: on February 12, 2013, in the first State of the Union address of his second term, President Barack Obama outlined a series of proposals that would increase access to high quality education. Among the primary proposals was one to build skills that lead to high quality, high-wage jobs:

> Tonight, I'm announcing a new challenge to redesign America's high schools so they better equip graduates for the demands of a high-tech economy. We'll reward schools that develop new partnerships with colleges and employers, and create classes that focus on science, technology, engineering, and math—the skills today's employers are looking for to fill jobs right now and in the future. (Obama, 2013)

This ongoing initiative came out of the seemingly desperate need for improvement of both science and math education. Since mathematics is seen as a "gateway" to success in STEM content fields, high emphasis is placed on mathematics in K-12 education. When mathematics is not learned properly in early years, making up for the gaps in learning becomes difficult, and those who have significant gaps rarely make it through more advanced math and science coursework (Flores, 2007; Lee, 2002). Because proficiency in science is highly dependent on math skills, the importance on improving math education holds weight not just for its own content proficiency, but the proficiency of science, and in turn, the entire educational pipeline of math and science education. Mathematics, then, serves as a "gateway" curriculum to advanced science, engineering, and technology coursework (Gottfried, Bozick, Rose, & Moore, 2014).

Paired with the emphasis on STEM, the other primary intervention to improve achievement is the Common Core. In 2009, the National Governors Association created a group to design new education standards that "provide a consistent, clear understanding of what students are expected to learn, so teachers and parents know what they need to do to help them" (Thomasian, 2011, p. 9). Over the course of the next two years, educational leaders from around the country came together to create the Common Core State Standards for both math and English, with new generation science standards also recently passed. These standards, copyrighted by the Governors Association as well as the Council of Chief State School Officers, were created, among other reasons, to ensure that students across the country had access to a rigorous educational curriculum. Further, these standards also created greater opportunities for rigorous mathematic instruction within the classroom. Endorsed by the National Council of Teachers of Mathematics (2013), the standards were largely a response to the critique that K-12 math instruction in the United States had a lot of content, but did not go into any of it with much depth (National Council of Teachers of Mathematics, 2013).

In order for students to achieve mathematical proficiency, five intertwined strands of proficiency are considered:

- Conceptual understanding,
- Procedural fluency,

- Strategic competence,
- Adaptive reasoning, and
- Productive disposition. (Kilpatrick, Swafford, & Findell, 2001; National Council of Teachers of Mathematics, 2013)

Mathematics in the United States traditionally has not enabled most students to develop the strands of math proficiency in a sound fashion. Only one, procedural fluency, tends to be emphasized in American classrooms. This has caused a great number of American math students to lack conceptual understanding and problem solving skills.

Further, within the intervention that is the Common Core, the issue of the methodology from which teachers instruct mathematics is front and center. Achievement of students can depend largely on the teacher they are assigned (Wayne & Youngs, 2003). Three consecutive years of effective teachers are necessary to make up the negative impact of one ineffective teacher (Tucker & Stronge, 2005). Teachers spending time instructing mathematics in a lecture-based format, emphasizing procedural fluency, has characterized math education in America (Siegler & Hiebert, 1999). In contrast, a great deal of research around mathematics points to the need for teachers to balance their practices where emphasis is placed not only on fluency, but also on problem solving and conceptual understanding (Boaler, 2002b; Hiebert, 2013). These practices are commonplace in high-performing math countries (Boaler, 2002a). Beyond content, the Common Core math standards also address the issue of math practices. Eight Core Standards of mathematical practice that describe the mathematical experiences and habits of mind that educators of mathematics should strive to develop within students:

- Makes sense of problems and persevere in solving them,

- Reason abstractly and quantitatively,
- Construct viable arguments and critique the reasoning of others,
- Model with mathematics,
- Use appropriate tools strategically,
- Attend to precision,
- Look for and make use of structure, and
- Look for and express regularity in repeated reasoning.

Further, early adolescence is perhaps the most pivotal time in a students' math education (Heller, Calderon & Medrich, 2003). Physically, students are going through the most rapid and dramatic developmental transformation they will ever experience. Intellectually, students are transitioning from concrete mathematical ideas such as learning the base-10 system and mathematical operations to more abstract ideas such as learning the concepts of fractions, equations, and algebraic expressions. As students learn more information, it creates more opportunity for gaps in knowledge to occur. If gaps cannot be filled within these grade levels during this stretch of time, they likely will never be filled. Thus, students will have far less chance for success when they get to high-school and college-level mathematics, and in turn, less likely to pursue a STEM-related field or be fully participatory citizens.

While many categories of variables that effect student achievement exist such as school quality and peer group (Hanushek & Rivkin, 2007), the effectiveness of a teacher is the single largest variable that directly impacts student achievement (Hanushek & Rivkin, 2007). Further, when categorizing the effectiveness of teachers, Wenglinsky (2001) as well as Wayne and Youngs (2003) argued that the teachers' background, the quality of professional development they receive, and the instructional practices they use in a classroom impact their effectiveness, and what students learn. Teachers often inherit student learning deficits, putting them in a position where teaching grade-level content and standards becomes more and more difficult because gaps in learning get larger and larger. Those gaps have high potential to impact their achievement in the future. This is especially true when students approach early adolescence, perhaps the most pivotal time in a students' math education. In short, a lot can happen in early adolescence. To know the impact of what happens at roughly the start to when it ends is an interesting phenomenon.

Statement of the Problem and Social Justice

The issue of the gap in math performance is an issue largely grounded in the concept of social justice. Gutiérrez (2007) defined the issue around the idea of "dominant mathematics" where the content learned gets valued in terms of high-stakes testing because of its importance in the view of the elite. The consequence of this is to encourage a static formalism of mathematics, rather than "critical mathematics," which acknowledges the position of students in society (Gutiérrez, 2007). The social justice component is two-fold. The first is around the issue of access. The lack of exposure to quality mathematics, a core content area, is seen as a gatekeeper for future academic success (Stinson, 2004). Moses and Cobb (2001) argued that mathematics is needed to be a full participant in society:

> As reading enabled educational, social, and political power in the mid-20th century, with the voter registration campaign of the *Freedom Riders* movement, today, mathematics has emerged as a civil right and a necessary component for educational access, political power, community empowerment, and full social participation. (p. 11)

When students learn procedurally-laden mathematics that is decontextualized from any real-world and relevant connections, students are done a disservice. This happens commonly and traditionally in American classrooms (Boaler, 2002a). This causes students to be less likely to be effective mathematicians, and in turn, less empowered citizens.

Beyond students having the right to an effective mathematics education, economic impact can be contextualized in terms of quality of life. A better-trained workforce is good for an economy. The addition of STEM jobs means a higher quality of life for those who are employed in a STEM field. Rothwell (2013) made the point that a person who enters a STEM field is more likely to make a higher wage than a person who has achieved a similar education level in a non-STEM field. The U.S. Bureau of Labor Statistics found that computer science occupations are among the fastest-growing job categories in the United States and that such jobs pay about 75% more than the national median annual salary (Margolis & Suarez-Orozco, 2014). This point was even taken further by Rose and Betts (2004) when they suggested that those who get further in math are predicted to make more money, particularly after taking Calculus.

Kahneman and Deaton (2010) argued that while money does not necessarily lead to happiness, being of low income exacerbates the emotional pain of trying circumstances, as well as being associated with a low evaluation of one's life and emotional well-being. While the dichotomies of economics and social justice may often present ideas, which create natural conflicts, in the case of math education, there is alignment between the two.

Education Production Functions and Inputs

When thinking about the problem of low achievement in math education, a few natural questions come up: how can math education be improved on a large scale? Where should the focus and energy go in fixing math education? What are the key levers that can dramatically improve math education for the better? When relating to economic terms, the questions can really be framed as a production function: fixing which specific inputs will produce the best math education outputs?

This study looked through the lens of an education production function. The idea of a production function in economics relates the output of a production process to various factors of production, otherwise known as inputs (Bowles, 1970). Education production functions are applications of this idea in relationship to the field.

Summers and Wolfe (1977) used an education production function as a way to look at the relationship between school absences and achievement on standardized tests. Hanushek and Rivkin (2007) and Hanushek, Kain, Markman, and Rivkin (2003) also published work on education production functions, arguing that teacher quality, school quality, and peers all have an effect on achievement.

When relating that question to math education specifically, a matter of figuring out what inputs effect the outcome of achievement emerges. A great deal of research has focused around three primary educational inputs that are seen to have some impact on student achievement: teacher quality, school quality, and peer groups. While quantitative research showed debatable results among the latter two inputs (Hanushek & Rivkin, 2007), teacher quality emerged as an input that impacted education outputs. Hanushek (2011) made the argument about the role of teacher quality in a student's future, specifically:

> A teacher one standard deviation above the mean effectiveness annually generates marginal gains of over $400,000 in present value of student future earnings with a class

size of 20 and proportionately higher with larger class sizes. Alternatively, replacing the bottom five to eight percent of teachers with average teachers could move the U.S. near the top of international math and science rankings with a present value of $100 trillion. (Hanushek, 2011, p. 479)

The Teacher, Early Adolescence, and Student Achievement

Math is important at any age, but the period between fifth and eighth grade is vital to the math education of students (among other things). Between fifth and eighth grade, permanent changes in math performance often occur (West & Schwerdt, 2012). Students are more likely to be successful in math in high school when their foundation of math skills in middle school is strong (Slavin & Lake, 2008; Wu, 2014). In contrast, students who come into more abstract mathematics classes such as Algebra I and Geometry without the prerequisite skills that were taught in lower grades often have little chance of mastering the content due to these gaps. Research does point to a relationship between elementary school math learning and future achievement beyond elementary school (Slavin & Lake, 2008; Wu, 2014).

Fifth grade traditionally represents the transition from elementary school to the beginning of middle school. Eighth grade traditionally represents the transition out of middle school into high school and likely more abstract, single subject coursework. Looking at the extent students are impacted by old experiences is an interesting idea in preparing students for more abstract mathematics.

A study by Wenglinsky (2001) looked at teacher practices as a predictor of student performance. In the study, he looked at three predictors of teacher effectiveness: personal experiences, instructional practices, and professional development. He argued that the size of the class and students' socio-economic status matter. To add to that are factors contributed by the teacher, what the teacher has experienced, what they do in class, and how they are trained, does all impact what the students achieve in the class (See Figure 1.).

These predictors are not dissimilar from those used by Wayne and Youngs (2003) in a review of research on teacher characteristics and student achievement gains, as well as those used by Cohen and Hill (2000) when recommending solutions around reform in mathematics. Professional development, background, and instructional practices are important when evaluating the effectiveness of instructors of math, and are within the domain of control of leaders in determining which teachers are in classrooms with students and how those teachers become better.

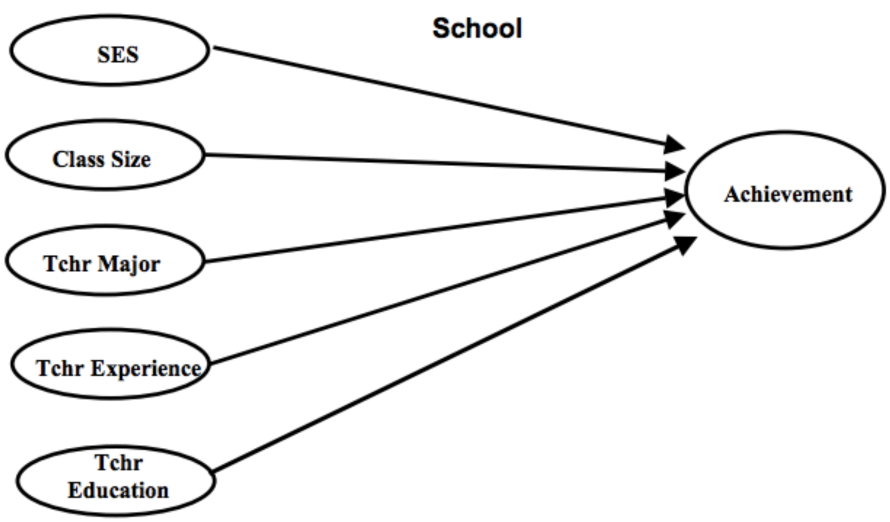

Figure 1. Factors that affect achievement
Note. Adapted from "Teacher classroom practices and student performance: How schools can make a difference," by H. Wenglinsky, 2001, Educational Testing Services (Report RR-01-19). Retrieved from Educational Testing Services website https://www.ets.org/Media/Research/pdf/RR-01-19-Wenglinsky.pdf

Purpose of the Study

The purpose of this study was to explore and analyze which fifth-grade teacher inputs were the most important predictors of future outcomes of eighth-grade math students. This quantitative study looked at mathematical achievement through the lens of an education production function. The three inputs analyzed were fifth grade teachers' background; perception of professional development and instructional practices; and the relationship of those practices to achievement in eighth grade math (See Figure 2.).

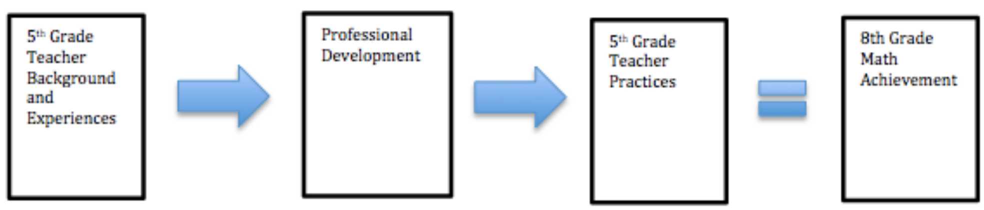

Figure 2. Relationship among variables analyzed

Research Questions

The following research questions guided this quantitative study of the predictors of eighth-grade math success:

1. To what extent do fifth-grade teacher background and experience predict eighth-grade student math performance?
2. To what extent do fifth-grade teacher professional development hours in mathematics and perception of the quality of their PD predict eighth-grade student math performance?

3. To what extent do fifth-grade teacher math instructional practices predict eighth-grade student math performance?

The first question is significant because of the current shift from old K-12 mathematics content standards to the Common Core. For teachers, the primary shift to Common Core is an emphasis less on the breadth of content and more toward a modality where “fewer topics of math are more” with a heavy emphasis around the eight standards of mathematical practice (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). Effective instructional practices have an obvious importance for the experience of students in a classroom. With that said, certain practices are more important than others in discerning the effectiveness of one practice over another.

In order for teachers to take effective steps in promoting mathematical proficiency in their classrooms, certain practices, such as group work and open-ended questioning, are more inclined to promote mathematical proficiency than others. Teachers are now asked to shift the modalities of their instruction so that students can engage in such habits of thinking as constructing viable arguments, mathematical modeling, and critiquing the reasoning of others (National Governors Association, 2011). Further, much research and conversation in math education swirls around student vs. teacher centered approaches to instruction (National Council of Teachers of Mathematics, 2013). One of the outcomes of the Common Core initiative is to shift teachers to instructional approaches that are found to be more effective (National Council of Teachers of Mathematics, 2013).

The second question is significant because the only proven way to shift existing teacher practices positively is to professionally develop them (Garet, Porter, Desimone, Birman, &

Yoon, 2001). There are five distinct features of high quality professional development (PD): content focus, coherence, collective participation, duration, and active learning. While this study only captured the idea of teachers' perception of professional development, the fact that the teacher has an opportunity to attend content-focused PD is valuable to measure, for this demonstrates that the teacher has the time to be professionally developed, which is reflective of highly effective teachers.

The third question is significant because of the documented link between teacher effectiveness and content knowledge, and to a lesser extent, experience (Ball, Thames, & Phelps, 2008). Content knowledge is shown to influence how teachers engage students with the subject matter as well as how they evaluate educational materials (Alonso-Tapia, 2002). Because teachers are the conveyers/facilitators of mathematics in the classroom, their depth of knowledge of the content represents the potential depth students can dive into the classroom.

Method

This quantitative study used a large data set provided by the United States Department of Education Statistics. The data set is entitled the Early Childhood Longitudinal Study, or ECLS-K for short (Tourangeau, Nord, Lê, Sorongon, & Najarian, 2009). This data set provided data for students in the United States from 1998 to 2007, including demographic information, school information, grades, standardized test scores and breakdowns, as well detailed teacher information. The data tracked the progress of over 21,260 students over the course of their K-8 education, providing data to analyze the relationships among a wide array of variables associated with each student. This study looked at the academic achievement of the 4,243 eighth-graders who were assessed at the end of the study.

From there, the data provided the basis of a relationship between student content knowledge and their overall achievement in eighth grade. The ECLS-K 1998 data set included an eighth-grade math assessment that was administered to students. The present dissertation research analyzed the relationship between individual student scores and various teacher quality predictors broken down into three subsections:

- Teacher Background and Experience
- Professional Development
- Teacher Practices

In order to find the relationship between the above variables and student achievement, descriptive statistics, multiple correlations, and multi-variable regression analysis were conducted to examine which predictors had the strongest relationships to eighth-grade math outcomes.

I looked at the descriptive statistics in order to analyze the fundamental characteristics of the teachers surveyed in the data set, with the intent of using the information to spell out general trends typical of fifth-grade teachers. For example, looking at the percentage of items such as the number of hours on average teachers spend on PD, the teaching practices teachers emphasized more than others, and the percentage of teachers with a math degree were all examples of possible patterns worth investigating.

With respect to correlation analysis, the following were conducted:

- Fifth-grade teacher Math PD predictors and eighth-grade student math test scores,
- Fifth-grade teacher characteristics and eighth-grade test scores,
- Fifth grade teacher practices and eighth grade test scores,

- Fifth-grade teacher experiences and eighth-grade test scores, and
- Fifth-grade teacher characteristics, practices, and PD predictors.

I ran a correlation in order to see the relationship between predictors and eighth-grade test scores. Running correlations between the two provided concrete evidence as to whether there was a relationship between the various predictors involved in the study and outcomes.

For the regression analysis, the following was conducted:

- All fifth-grade predictors (teacher characteristics, practices, and PD) in relationship with eighth-grade math test scores

I ran multiple regression analyses because I was looking for the overall relationship between fifth-grade teacher math inputs and eighth-grade math outputs. A multiple variable regression analysis accomplished this. In this case, the dependent variable was eighth-grade test scores and the independent variable was teacher perceptions of PD. While correlations of the predictors and test scores provided valuable information regarding whether a relationship existed, the regression analysis demonstrated whether those predictors collectively had any type of direct linear relationship with eighth-grade math achievement. This process helped answer the larger question of how much impact fifth-grade math instruction had on eighth-grade math outcomes.

Delimitations, Limitations, and Assumptions

A primary delimitation of this study was the issue of whether—based upon the data set provided—can any accurate conclusions be made about urban math education and performance? This data set was large, thus minimizing the effect of a skewed data set. The sample size provided a rich amount of information with a wide sample of variables potentially impacting achievement. The information was collected by a well-regarded source, the National Center for Education Statistics, between 1998 and 2007.

This study assumed that the data were accurate and collected properly. The National Center for Education Statistics took the data set and organized it into a file that researchers can use to investigate and draw conclusions. Considering the stature of the institution and the volume of researchers that use the data set for research, it was acceptable to assume that the data were reliable.

This study also made an assumption that "success" in eighth-grade math can be largely linked to proficiency on a given state content exam. An overwhelming amount of literature has challenged the idea of standardized testing as an optimal mechanism to measure student learning (Kohn, 2000; Popham, 2000). A great deal of current debate in education centers on the overemphasis of standardized testing driving the narrative of K-12 public education (Ravitch, 2011). While this study used standardized test scores as a means to quantify academic achievement in mathematics, academic achievement admittedly should be measured in multiple ways using multiple modalities. The use of standardized tests to measure progress only gives a quantified measurement of an outcome that does not consider the full context of a student's academic progress.

The most obvious limitation to this study was the fact that sixth- and seventh-grade math inputs were not available. Because the ECLS-K 1998 data were collected during students' kindergarten, first, second, fifth, and eighth grade years, and not during sixth and seventh grade, the time lapse leaves open the possibility that sixth and seventh grade variables affected the data in some way, shape, or form. The study controlled for this by looking at the direct relationship between fifth grade and eighth grade. While data from sixth and seventh grade may have been illuminating, they were unnecessary in order to see that indeed previous experiences in mathematics matter in later years.

The study was limited to the inputs that the data set provided. While the data set provided a large variety of factors that could affect eighth-grade math achievement, those factors were finite. Many other variables could indeed affect math achievement. For example, deeper questioning around professional development that categorizes the type of professional development teachers received in mathematics instruction could be informative in disseminating what type is effective.

Definitions

The important definitions pertaining to this study follow those provided by the Office of Civil Rights Data Collection 2009-2010 (CDE) unless otherwise noted.

Advanced Mathematics: Advanced mathematics includes the following: Trigonometry, Trigonometry/Algebra, Trigonometry/Analytic Geometry, Trigonometry/Math Analysis, Analytic Geometry, Math Analysis, Math Analysis/Analytic Geometry, Probability and Statistics, and Pre-calculus.

Classroom Teacher: A teacher that provides instruction, learning experiences, and care to students during a particular time period or in a given discipline. School principals and guidance counselors are not considered classroom teachers.

Input values: Something put into a system or expended in its operation to achieve output or a result (Mankiw, 2011).

Output values: As a term for a tangible good or an intangible service that is the end result of the production/resource transformation process associated with an input (Mankiw, 2011).

Public School: An institution that provides educational services and meets all of the following criteria:

- Has one or more grade groupings (prekindergarten through 12) or is ungraded,
- Has one or more teachers,
- Is located in one or more buildings,
- Has an assigned administrator(s),
- Receives public funds as its primary support, and
- Is operated by an education agency.

Public schools include charter schools that receive public funds from state or local government. Public schools also include alternative schools such as schools for students with academic difficulties.

Academic achievement: The extent to which a student, teacher, and/or a school has reached a set goal.

Structure

This study is structured as follows. Chapter One introduced the context of the work. Chapter Two provides an academic background on mathematical outcomes and teacher quality inputs. Chapter Three describes the methodology used in this study. Chapter Four explains the results of the study. Chapter Five provides a discussion of the conclusions drawn from the research, along with recommendations for future educational research and policy.

CHAPTER TWO

LITERATURE REVIEW

Overview

This chapter reviews literature on the following topics relevant to this research study:

- The effects of early adolescence on social, physical, and academic development,
- Fifth-grade teacher background and mathematics,
- Fifth-grade teacher practices and mathematics,
- Professional development and mathematics,
- Large data sets and student outputs,
- Social justice and mathematics, and
- Education production functions.

The purpose of this study was to explore and analyze which fifth-grade teacher inputs were the most important predictors of future outcomes of eighth-grade math students. The theoretical framework for the study was an education production function. In looking through the lens of an education production function, a trend in the literature emerged: using regression analyses to answer research questions. This was the context in which the literature review was developed.

The Effects of Early Adolescence: Social-Emotion, Academic, and Physical

During early adolescence, students go through a variety of changes. Two of the most obvious changes are in the school they attend and the physical changes the children go through. For a majority of American children, a transition occurs from elementary school to middle school. This transition is difficult due to the anxiety around everything from finding their lockers and opening them, to getting to class on time, to having to make new friends (Niesen &

Wise, 2004). This is compounded in complexity by physical changes that occur with children. A child's brain size can increase by almost 40% (Niesen & Wise, 2004).

Further, according to Eccles (1999), as they become older, two possible consequences may occur around academic motivation. Eccles (1999) framed the issue of academic motivation into two distinct questions: "can I do the task?" and "do I want to do the task?" If the answer is no on the first question, students tend to engage in self-protection strategies that are meant to preserve self-worth. A consequence of such can be academic failure, withdrawal from the school learning agenda, and dropping out of school. The consequence of an answer no to the second question is students engaging in avoidance strategies or putting forth minimum effort (Eccles, 1999).

This leads to looking at child academic development. Beyond that, in mathematics, the transition in early adolescence mathematics is critical to future aptitude. Math curriculum generally features concrete concepts such as integers and base-ten operations (California Department of Education, 2013). Eventually, by the seventh and eighth grade, students begin to move to more abstract math ideas such as adding and subtracting fractions, multi-step equations, and if students take Algebra as eighth graders, systems of equations and quadratic functions (California Department of Education, 2013). This makes the learning that takes place in early adolescence, before high school, vital to future student success.

Usher and Kober (2012) identified four primary factors that influence this transition: gender dynamics, merging student groups, social skills, and parental involvement.

A majority of the research on transitioning from elementary to middle school focused on comparing K-8 schooling to middle schools. Byrnes and Ruby (2007) made the case that K-8 schools can facilitate slightly better outcomes than middle schools. While there are gains created because of the structure, they are small, and in the estimate of the researchers, neither a silver bullet nor a cause in itself for wide-scale conversions in districts. Further research also pointed to the socio-emotional transitions associated with moving from elementary to middle school, such as emotional coping of puberty, structural transition from an elementary to middle school, and possible difficulties establishing meaningful relationships within shorter class periods (Fitzgerald, 2006).

Base-10 System, Fractions, and Prerequisite Skills

Rote and concrete mathematics in elementary school have been long taught and emphasized (Siegler & Hiebert, 1999). Students begin having difficulty with mathematics when math becomes more abstract. This can often begin in early grades when students begin studying the Base-10 systems. Concepts such as place-value, subtraction, and multiplication move from concrete ideas to abstract thinking (Briars & Fuson, 1990). However, students may encounter difficulty learning these ideas due to ineffective knowledge or time engaging in these topics (Briars & Fuson, 1990). It is at these early stages where gaps in learning mathematics may arise.

Siegler et al. (2012) conducted a large longitudinal study over a six-year time frame that spanned two countries (the United States and United Kingdom). The researchers used two nationally-representative longitudinal studies: the British Cohort Study and the Panel Study of Income Dynamics Child-Development Study (Siegler et al., 2012). The study focused around a hypothesis that fractions are uniquely predictive of later knowledge of Algebra. In the study, the most profound conclusion made was elementary school students' knowledge of fractions uniquely predicted overall achievement in high school five and six years later—even after controlling for other variables that could affect achievement such as general intellectual ability, other types of math knowledge, socioeconomic status (SES), and family education (Siegler et al., 2012). They recommended that because acquisition of knowledge of fractions is crucial to numerical development, it deserves a central position within the academic development of students, and a central place in math curriculum.

Success in mathematics is largely predicated on pre-requisite skills such as mastery of trinomial factoring, solving multi-step equations, and mathematical modeling skills (Boaler, 2002a). Those are typically skills learned before students get to Algebra II. Without pre-requisite knowledge, particularly in high school math, success is nearly impossible, and upper level K-12 math teachers have to scaffold their instruction in such a way where it almost inevitably "waters down the curriculum" (Boaler, 2002b, p. 12). This can also be a problem in elementary and middle school mathematics where students may lack rote, procedural or conceptual knowledge necessary to master concepts such as multiplication or one-step equations involving inverse operations.

Cognitive Development

The transition from elementary to middle school comes at a crucial time for brain development. Young boys and girls are transitioning from becoming concrete learners to abstract learners (Beaton et al., 1996). The period of brain growth marks the beginning of a person's ability to do problem solving, think critically, plan, and control impulses (Beaton et al., 1996).

At the beginning of middle school, the brain's primary growth occurs in the prefrontal cortex, where humans make central decisions (Beaton et al., 1996). As adolescence begins, students tend to take more risk-taking behavior, which leads to more impulsive and disruptive behavior that in turn potentially could affect student learning (Simons-Morton, Crump, Haynie, & Saylor, 1999). Further, increases in gonadrotropin-relasing hormones (GnRH), lutenizing hormone (LH), and follicle-stimulating hormones create emotional imbalance, further complicating learning. All of this occurs during puberty, when the body grows rapidly, and in-turn the brain. During this time, the brain develops more capacity, begins retaining more memory, and is able to engage in more abstract thought.

This affects students in profound ways unlike at any other stage in development. Students' academic abilities now have a higher ceiling compared to when they were younger because they are able to engage in more sophisticated, higher-cognitive thinking (Eccles, 1999). They also begin to view themselves differently, understanding internal psychological characteristics of themselves and others. This drives them to make decisions such as making friends around their own personal characteristics such as common interests (Eccles, 1999).

Teacher Inputs

The primary focus of this study was on how fifth-grade teacher inputs affected eighth-grade student math outputs. The three primary inputs were modeled after the indicators used by both Wenglinsky (2001) and Wayne and Youngs (2003). The inputs were teacher background, professional development, and instructional practices.

Teacher Background

In 2001, the Conference Board of Mathematical Sciences in the United States reported evidence of a troubling cycle in which too many prospective teachers enter college with insufficient understanding of mathematics and mathematic instruction, have little college instruction focused on the mathematics they will teach, and then enter their classrooms inadequately prepared to teach mathematics to their students (Conference Board of Mathematical Sciences, 2001).

According to research by the Teacher Education and Development Study in Mathematics (TEDS-M) (TEDS-M, 2009), future middle school mathematics teachers prepared in programs focused on secondary schools (grades six and above) had dramatically and significantly greater mathematics knowledge scores than future middle school mathematics teachers prepared in K-8, or six-through-eight certification programs.

Perhaps of largest concern is the content preparation of elementary school math teachers. Masingila, Olanoff, and Kwaka (2012) made the point that many prospective elementary school teachers do not receive adequate experiences from their teacher education program to develop deep conceptual knowledge of mathematics. In a survey given to over 800 teacher preparation institutions, 80% of those institutions offer math content courses, and more than half of the institutions surveyed state they require teachers to take math content courses.

However, the quality of this preparation is seemingly lackluster. A majority of the institutions that provide prospective teachers math education are not following the National Council of Teachers of Mathematics (2013) recommendation of taking nine credits of mathematics specifically designed for the teacher. Further, these same institutions, as a majority, place the responsibility on college faculty who lack experience in teaching elementary school with instructing future elementary school math teachers, which opens itself to a disconnect between teacher instruction and student needs. The surveys imply that the teachers lack of experience in math education classes fail to engage teachers as students of math themselves. The obvious consequence is that teachers who are not prepared to teach students crucial foundational mathematics concepts, such as number sense and fractions will, in turn, produce students with large gaps in mathematics understanding and performance.

Pre-Service Teacher Preparation/Credentialing

In a 2005 study, Darling-Hammond, Holtzman, Gatlin, and Heilig argued that teachers with standard certification were found to be significantly more effective in raising student test scores than teachers without certification or with substandard certification. The study, which included measuring the effectiveness of Teach for America interns, found that certified teachers outperform alternatively certified teachers (e.g., TFA interns). Beyond that, labor market conditions, such as training subsidies, competitive salaries, and supportive administrators, are important variables to new teacher success and sustainability (Darling-Hammond, Holtzman, Gatlin, & Heilig, 2005). Darling-Hammond et al. (2005) concluded that states and districts need to provide strong, efficient, and affordable preparation routes so teachers can be competent when they enter the profession and are willing to stay in the profession long term. This research was backed by a number of others who argued teacher pre-service training needs reform (Franz & Hopper, 2007; Kennedy, 1999).

At a macro level, research conducted by Ingersoll (2001) showed evidence that science, technology, engineering, and mathematics (STEM) content teachers, as a whole, tended to be among the lowest achieving college graduates. Ingersoll (2001) showed that the bottom 25% of schools in the country employ among the bottom 10% of math and science graduates with respect to college GPA. What this means is that students in elementary and middle school classrooms are getting among the lowest academically-achieving math teachers in the teaching pool. These teachers lack the prerequisites, such as content knowledge (Ingersoll, 2002), adaptability (Billett et al., 1999), and reflective skills (Loughran, 2002) to be effective math teachers.

Years of Teaching Experience

Research on years of teaching experience and its relationship to student learning is mixed. Some researchers indicated that some experience has an impact on student outcomes for both math and English. Kane, Rockoff, and Staiger (2008) analyzed a data set of New York City public school teachers. Here, using a value-added comparison based on standardized tests, they found that teacher effectiveness significantly improved between years one and two, and then showed significant gains in student performance through a teacher's third year, and with math, the fourth year, after which, effectiveness results tended to flatline (Kane, Rockoff, & Staiger, 2008). This research was partially supported by Huang and Moon (2009). When looking at a sample of second graders in the mid-Atlantic states, they found that years of teaching experience as a whole were not statistically significant as related to academic achievement. However, additional years of experience at the same grade level did add to a direct positive impact on student achievement for up to 20 years of experience. Their focus was primarily on reading performance, and math was not looked at as closely.

In contrast, Buddin and Zamarro (2009) argued there is no relationship between teaching experience and student performance. According to their study, using a value-added model based on longitudinal research done in Los Angeles schools, teacher experience was weakly related to student achievement. In looking at schools in low SES areas, they found little difference in students who have highly experienced teachers as opposed to inexperienced teachers. However, in this study, the researchers pointed out that high levels of teacher experience may, nonetheless, have important benefits for schools. Teacher retention saves money in recruiting and training of teachers. These savings may affect resources that could indirectly be used for supplies, technology, and more staff, and, in turn, could improve student achievement.

Content Knowledge and Mathematics Degrees

Research has indicated a relationship between teacher effectiveness and content knowledge. Ball, Thames, and Phelps (2008) found when controlling for specific covariates, teachers' math knowledge was significantly related to student achievement. This finding was consistent with other international math studies (Ngo, 2013), which also made the argument that pedagogical content knowledge is significant with respect to student learning.

Perhaps more compelling, Wayne and Youngs (2003) conducted a review of the literature on teacher characteristics and achievement gains. In their review, they found upon analyzing the research of seven studies on gains in math and English scores and their relationship to state licensing exams and teachers' own high school ACT scores, teacher test scores did matter (Wayne & Youngs, 2003). Teachers who had higher standardized test scores of their own tended to have students who outperformed students taught by teachers who had lower state required test scores.

Research on the effects of upper-level education and student achievement have shown little connection (Hanushek, Rivkin, Rothstein, & Podgursky, 2004). Research has found that a master's degree had no systematic relationship to teacher quality as measured by student outcomes. There also seemed to be little connection to the number of credits post-bachelor degree, a traditional approach for providing compensation to teachers (Hanushek et al., 2004).

However, when it comes to math, there seems to be some relationship. Wayne and Youngs (2003), in their analysis of teacher effectiveness, studied four determinant studies that looked at the relationship between particular degrees and coursework with student learning. Based on their analyses, which included the vetting of methodology of four separate studies, they concluded that students at the high school level learn more from teachers who possess either an undergraduate and/or graduate degrees in mathematics as opposed to other disciplines.

Teacher Professional Development

In an age in which teacher effectiveness is seen as the most important variable for student learning (National Center for Education Evaluation, 2011), what makes up teacher effectiveness has become an important question. A growing body of research has focused on influences that affect the outcomes of professional development (PD). Looking at PD in the content area of math, some specific characteristics make for effective outcomes. PD is more effective when sustained over a long period of time as opposed to short-term one-day workshops that are not often reinforced (Killion, 1998). According to Ball (1997) and Garet, Porter, Desimone, Birman, and Yoon (2001), PD is also more effective when the following characteristics are applied:

- rich opportunities for discussion and reflection,
- an open, learner-centered implementation component,
- an inquiry stance taken by the facilitators,
- student-centered mathematics learning activities, and
- inclusion of authentic and readily adaptable curricula.

This is similar to Abdal-Haqq (1998), who also identified the above characteristics and included other features such as PD being ongoing, including training practice, feedback, encouraging school-based and teacher initiatives, and recognizing teachers as professionals/adult learners.

The research has shown a distinction between low-SES math professional development, and high SES. When looking at low-SES schools, many scholars have been concerned with the impact of training teachers to use culturally relevant pedagogical approaches. Such an approach has shown mixed levels of effectiveness. Rubel and Chu (2012) did an observational study in which teachers were trained using CureMap, a professional development program that trains math teachers to tailor instruction based around students' cultural background. CureMap addressed identity by guiding teachers to center instruction on students' experiences in terms of problem contexts, representations, and/or participation structures that build on students' experiences (Rubel & Chu, 2012). Observers attempted to quantify the degree to which seven teachers were implementing the program in their classrooms. After 68 observations, they found that most of the lessons teachers used did not use the CureMap model and focused on instruction with memorization or procedural knowledge without connections to concepts (Rubel & Chu, 2012).

However, there is not much research that compares and contrasts the two explicitly. One study conducted by the United States Department of Education looked at the effect a consultant-based PD had on seventh-grade math teachers in the area of rational numbers (National Center for Educational Evaluation, 2011). The study distinguished between Title-I and non-Title-I teachers. The results were measured quantitatively. However, using student pre- and post-tests as a measurement and cross-checking the improvement with expected results, no significant gains were made for either Title-I or non-Title-I teachers (National Center for Education Evaluation, 2011).

One approach to PD that showed promise with low-SES students was the promotion of math dialogue and academic language in math classrooms. Staples and Colonis (2010) looked at a professional development program in which math teachers develop academic language, learn student engagement methods of argumentation, and make math dialogue accessible to students whatever their level may be (Staples & Colonis, 2007). Teachers did a three-day PD workshop, which was voluntary and supported contingency theory. From there, students' success was measured within the program using a pre- and post-test assessment. They measured student success quantitatively by giving students a pre- and post-test assessing academic language, argument, and not low-level procedural or memorization skills (Staples & Colonis, 2007). The results were that students showed significant improvement in both academic and argument/ logical reasoning skills. Many teachers believed the success of the students was largely because teachers did not feel bogged down "teaching to a test." One interesting note was the main reason administrators allowed teachers to implement the methods into the classroom was because PD involved some multiple choice questions—the same format as standardized tests.

Higher SES school professional development tends to be different than low SES school professional development. In one study from Australia, which looked at teacher technology training, Hartsell, Herron, Houbin, and Rathod. (2010) made the point that technology tools can help students learn, but teachers have to be confident of their learning. In a four-week seminar, 60 teachers learned to use various mathematics programs and technology tools in their classrooms. The result was that teachers were proactive and motivated to continue to learn about technology and realized they were able to use it to advantage in their classrooms. The technology was high-end (Smartboards, document cameras, and computer software). It is less likely that a low-SES school would be able to afford these resources (Duncan & Murnane, 2014).

For math teachers at mid/high SES schools, content different approaches have proven to be effective. For example, Zwiep and Benken (2012) conducted a study of five districts to make the case that math teachers can benefit from a content-driven professional development. In the study, when teachers were able to let go of any defensiveness about learning mathematics, they were able to improve their content knowledge, and in turn feel more confident about their ability to deliver the material to students. All of the teachers were voluntary participants. In that qualitative study, teachers' disposition towards the content improved, according to a survey taken about their feelings before and after the professional development. Upon completion, teachers were, as expected, more positive and had more confidence toward the PD (Zwiep & Benken, 2012).

Instructional Practices

The impact of teachers on students has a cumulative effect. Much of what makes for effective teaching are the strategies, tools, and ideas—otherwise known as "practices"—that teachers use in their classrooms. The research on instructional practices in mathematics is rich and extensive.

Shellard and Moyer (2002) saw three primary features to effective teaching of math: teaching for conceptual understanding, developing children's procedural literacy, and promoting strategic competence through meaningful problem-solving investigations. With that, the research around instructional practices in mathematics point to a need for American math teachers to move their practice towards conceptual ideas and away from emphasis on rote memorization and procedural fluency (Wu, 2014). American math teachers tend to approach curriculum in a procedural and lecture-oriented way rather than emphasizing conceptual understanding in a setting where ideas and conversations can take place (Siegler & Hiebert, 1999). This is especially true in settings where the children in low-income and impoverished households reside. Wu (2014), along with Boaler (2002b), pointed to the success of countries such as Japan, South Korea, and Finland, which emphasize more conceptual ideas and problem solving tasks in their mathematics curricula. These authors did this to demonstrate where American math curricula is lacking, and international mathematics curricula has an edge.

In her well-regarded work, Boaler (2002a) conducted longitudinal studies of English math students learning math from different approaches. These studies found that students who were actively engaged in mathematics learning, using problem-solving and reasoning about methods, achieved at higher levels and enjoyed math more than those who engaged passively by practicing methods that a teacher had demonstrated. The later approach (traditional) is one that is most often used in the American math classroom. The former (reform/inquiry-based) is the approach emphasized and advocated under the Common Core (Wu, 2014) math standards.

Strategic Grouping

Much of the research around strategic grouping centered on the benefits of homogenous grouping as opposed to heterogeneous grouping. The line of thought around homogenous grouping was when students are in groups with students of the same interest or skill set, differentiated, more personalized instruction was easier to plan for, and in turn, met the students' more specific needs (Tomlinson, 2008). The research on this topic focused on the idea of "tracking." The popular sentiment, among researchers, was that ability grouping with high-achieving and gifted students had benefits for that sub-group (Feldhusen, 1989). By providing targeted instruction that is more rigorous, these students will learn more (Feldhusen, 1989).

Beyond that, Slavin and Karweit (1985) found that some forms of grouping may result in increased student achievement. Slavin and Lake's (2008) review focused on grouping plans. They concluded that grouping exclusively by ability does not improve achievement. However, certain conditions around grouping by ability may have some value. For example, students grouped heterogeneously for most of the school day, but regrouped according to ability for one or two subjects, improved achievement in those areas for which they are homogeneously grouped. Also, non-graded instruction—instruction that groups students according to ability rather than age and that allows students to progress at their own rates—resulted in improved achievement. This conclusion was supported by Hoffer (1992), who found that high-achieving groups have a weak positive effect while low-achieving groups have a strong negative effect.

Further, Lou, Abrami, Spence, Poulsen, Chambers, and d'Apollonia (1996) found that within-class grouping benefits student achievement in mathematics. The study showed small correlations for both small group learning as well as homogenous grouping. They then argued as a result of their study that grouping was largely contingent on how the groups were implemented. Specifically, the focus was on what tasks students were doing in groups, and how well-designed the activity was.

Student-centered Instruction and Teacher-directed Instruction

The research on the advantages of student-centered and teacher-directed instruction, specifically, which one is more valuable and important, is mixed. According to Morgan, Farkas, and Maczuga (2015), direct-instruction is a more important component:

> For students without math difficulties (MD), more frequent use of either teacher-directed or student-centered instructional practices was associated with achievement gains. In contrast, more frequent use of manipulatives/calculator or movement/music activities was not associated with significant gains for any of the groups … an important contribution of our work is that we find that teacher-directed instructional practices are associated with achievement by both students with a prior history of persistent MD, as well as those with a prior history of transitory MD. In contrast, other, more student-centered activities (i.e., manipulatives/calculators, movement/music) were not associated with achievement gains by students with MD. (Morgan, Farkas, & Maczuga, 2015)

This finding was consistent with other research on the topic. Having said that, many have argued that what determines whether student-centered instruction is effective or not is largely based on how it is implemented (Moore, 2014). Student-centered and small group instruction helps develop communication skills, a more intimate exchange of ideas, and thus, higher-order critical thinking skills, all of which in theory, supports student learning (Johnson & Johnson, 1986; Peterson & Miller, 2004).

Problem Solving/Rich Tasks

Hewson (2014) defined a rich mathematical task as something that when mediated in certain ways, produces certain kinds of mathematical actions and behaviors in students. It can be an open-ended problem, with a variety of possible solution paths that range from simple to complex. Hewson (2014) expanded on this idea a bit further:

> Rich tasks open up mathematics. They transform the subject from a collection of memorized procedures and facts into a living, connected whole. Rich tasks allow the learner to 'get inside' the mathematics. The resulting learning process is far more interesting, engaging and powerful; it is also far more likely to lead to a lasting assimilation of the material for use in both further mathematical study and the wider context of applications. (Hewson, 2014, p. 12)

Under the Smarter Balance Common Core assessment system, 21 states are using the math exam that features a problem-solving performance task that is 60% of the total value of the exam (Smarter Balanced Assessment Consortium, 2015). Research evidence indicated that students who were given opportunities to work on their problem solving skills enjoyed the subject more (Boaler, 2002a), were more confident, and were more likely to continue studying mathematics, or mathematically-related subjects (Boaler, 2002a).

Schoenfeld (2014) argued that problem-solving tasks in mathematics have several benefits for students, such as increasing students' math knowledge, granting access to productive heuristic strategies for making progress, developing self-monitoring skills, and increasing a positive self-belief around mathematics. Schoenfeld (2014) actually took this idea a step further and introduced an idea that problem-solving tasks should be regularly used as a form of formative assessment. As a side note, he and other scholars and educators have advocated the use of formative assessment lessons (FAL) that have been piloted and reviewed for the public use of teachers. The resources are available readily online (Mathematics Assessment Project).

Procedural Fluency and Conceptual Understanding.

The National Council of Teachers of Mathematics (2013) states that procedural fluency is "the ability to apply procedures accurately, efficiently, and flexibly; to transfer procedures to different problems and contexts; to build or modify procedures from other procedures; and to recognize when one strategy or procedure is more appropriate to apply than another." Procedural fluency tends to be heavily emphasized in American math classrooms. Many would argue that it is overused. This supports research that showed too much practice too soon can be ineffective or lead to math anxiety (Isaacs & Carroll, 1999).

The National Math Advisory Panel concluded that while American students have a reasonable factual and procedural knowledge of mathematics, as a whole, they have poor conceptual knowledge (Willingham, 2009). Several studies demonstrated that students had an incomplete understanding of fractions and the base-10 number system (Duncan et al., 2007; Sanders & Rivers, 1996; Willingham, 2009). Conceptual understanding tends to be more difficult than other aspects of teaching mathematics because it tends to build on previously learned ideas that students should already know (Willingham, 2009).

The traditional approach to teaching mathematics tends to involve students receiving information from a teacher who does a series of fluency problems. Rarely do traditional textbooks put an emphasis on problems involving conceptual knowledge (Hiebert, 2013; Wu, 2014). Further, since the advent of standardized testing, the vast majority of traditional tests tended to assess fluency-oriented problems (Wu, 2014). This void tends to exacerbate American students' gaps in knowledge around conceptual understanding (Hiebert, 2013; Wu, 2014). However, leaving procedural fluency out of the system leaves students with gaps in their knowledge. While likely overemphasized in American classrooms, the necessity for it should not be questioned. In short, conceptual understanding without procedural fluency leaves students with an ineffective knowledge base (Hiebert, 2013). Procedural fluency without conceptual understanding is shallow. Both approaches to learning are necessary for students to gain full competence of mathematics. The balance of the two with problem solving is what many would argue entails a rigorous mathematics classroom (National Council of Teachers of Mathematics, 2013). It is a classroom of all three approaches that most experts would agree promotes the highest levels of learning in students.

The Use of Technology

One practice worth noting is the use of technology in education. One of the major arguments around education in popular culture is that 21st century classrooms look very similar to those of the 19th and 20th centuries (Boaler, 2002b). A significant body of research exists connecting student learning and technology (Boaler, 2002b). However, because innovation moves at a quick speed, with every new innovation (such as iPads and web-based curricula) what defines effective use of "technology" can quickly change. The research on blended learning points to two primary ideas: providing balance between direct and online instruction and digital activities that add value to instruction (Picciano & Spring, 2013). In the scope of this study, the use of computers was inquired about with teachers. However, because of the movement of technology and learning, any conclusion around technology in the classroom must be taken in appropriate context.

Having said that, research on the use of calculators has yielded positive results. Calculators help students focus on conceptual mathematic ideas by reducing the cognitive energy needed for laborious calculations (Kastberg & Leatham, 2005). This is even true as early as first grade (Polly, 2008), where students were able to explain their work and answers more clearly with the use of calculators. Graphing calculators in particular help provide students a quick visual of math ideas, shifting students' thinking away from calculations and closer to conceptual mathematic ideas (Kastberg & Leatham, 2005).

Race and Class and Social Justice in Mathematics

There is an extensive body of research that looks at social justice and mathematics (Frankenstein, 1983; Gutstein & Peterson, 2005; Wager & Stinson, 2012). The scope of that research is vast, rich, and with merit. The primary relationship between social justice and mathematics as it relates to this study is in the idea that effective mathematics is a social justice issue for all students.

Paulo Freire argued that students were educated in a way similar to a banking model, where information was simply deposited into a student's mind (Freire & Ramos, 2000). This is a polar-opposite contrast to the vision that students gaining information to solve problems can be self-empowered and organize for social and political reform (Stinson, 2004). It is not unlike the current state of math education in America, where the traditional approach of a teacher leading a discussion of procedural fluency and specific mathematical terms has been accepted as the "signature" way in which mathematics is taught (Hiebert, 2013). In supporting the idea of using mathematics as a tool of critical thinking, the National Council of Teachers of Mathematics laid out a series of effective teaching practices, which teachers should model (National Council of Teachers of Mathematics, 2013; Stinson, 2004). These practices were slightly modified and embedded in the Common Core State Standards of Mathematical Practice. The goal of these standards was to shift the dichotomy of the mathematical classroom so students leave their K-12 mathematics education able to make connections to their world, and use mathematics as a critical thinking tool (Stinson, 2004).

The conversation about social justice and education is incomplete without addressing the direct impact poverty plays on children and their education and how it exacerbates already existing gaps in math education that exist even for better resourced subgroups. A broad array of longitudinal research exists around urban school quality and achievement (Ross et al., 2004). A 2006 study by Balfanz and Byrnes followed four cohorts of students from three high-poverty schools from fifth through eighth grade. They found that when students experienced one or more of the following, a string of good teachers, newfound self-confidence, increased effort, and better attendance, effective teaching and learning experiences occurred. However, more often than not, students in high poverty areas were less likely to experience a high-gain classroom where their achievement could move them forward. More often than not, their progress continued to regress due to continuous assignment to less-qualified teachers, higher likelihood of falling into the wrong peer group, and being enrolled in a school with limited classroom resources. Students in high-poverty schools were regularly denied the mechanisms such as non-evaluator peer coaching, organizational reforms like small-learning communities, and teacher teams, which are characteristics of systems that govern classrooms and move achievement forward.

One other broad factor worth mentioning is the impact of school quality in urban and high-poverty schools. Previous research overwhelmingly showed when delineating between achievement and schools with low-SES populations, student achievement is lower (Hanushek, Kain, Markman, & Rivkin, 2003). This along with the large body of literature around the ideas of race and class in education is widely published in scholarship, and the discussion extends far beyond the scope of the present study (Grant & Sleeter, 1986; Moses & Cobb, 2001).

Berliner (2011, 2012) argued that poverty as a whole has a larger effect on a child's education than any series of variables a school can provide. In looking at math students in the top 50% of SES schools, and comparing it to students in the bottom 50%, there is overwhelming evidence that the two variables, SES and academic achievement, have a relationship (Berliner, 2006). The top schools in the United States produce among the strongest math students in the world (Berliner, 2006). While the bottom 25% of students score worse than the majority of countries in the industrialized world (Berliner, 2006). He largely attributed the number of hours students are in their home surroundings as opposed to the hours they are in school (Berliner, 2006). Berliner made the point that no matter the quality of the school, and the teachers that educate students, they are less predictive of student outcomes than is poverty. He argued that school systems, social safety nets, and living wages need to provide people in poverty more dignity and greater opportunity for successes in society.

In low-SES areas, teacher quality ends up becoming a factor in student learning. A recent study showed that the bottom 25% of public schools in the country employed among the bottom 10% of math and science graduates with respect to college GPA (Ingersoll, 2001). Thus, the students in those classrooms are not getting well-qualified teachers. These teachers, often well intentioned, lack the prerequisites to be effective in content knowledge, adaptability, reflective skills, and at times, overall motivation and work ethic. Beyond that, a large body of evidence has indicated that many elementary school teachers have less than adequate backgrounds necessary to teach math (Glod, 2007; Greenberg & Walsh, 2008; Ingersoll, 1997).

Finally, the better one's math skills, the more likelihood students have an opportunity for higher paying employment. Levine and Zimmerman (1995) argued that higher-level math classes increase the likelihood that they enter better compensated technical fields. This was particularly true for female students. Another study showed the more math courses students took in college, the more likely they were to graduate from college (Rose & Betts, 2004). Finally, the same study showed that students made roughly $4,000 annually for every math class a student took after Algebra.

Large Data Sets on Math Scores

Most studies on using large data sets to disseminate findings on math education have come to a similar conclusion: as a whole, American children lack access to quality math education, and the lack of quality is further exacerbated in urban schools (Balfanz, Herzog, & MacIver, 2007). The most obvious piece of evidence to support this claim is the most recent TIMMS (Trends in International Mathematics and Science Study) results, which showed when taking the average score, the United States was 24th in the industrialized world. This is a drop from when students take the test in fourth grade—where the United States ranks 14th (Balfanz & Byrnes, 2006).

In a write-up of the TIMMS study, Balfanz and Byrnes (2006) profoundly stated that it is in the middle school grades where achievement gaps in mathematics suddenly become achievement chasms. The authors emphatically state the relationship between elementary school and middle school has a direct effect on student achievement (Balfanz & Byrnes, 2006). Many students end middle school ill-prepared to succeed in a rigorous sequence of college preparatory mathematics in high school and, as a result, have difficulty achieving success in mathematics in high school and beyond (Balfanz, McPartland, & Shaw, 2002).

In 2012, The Program for International Student Assessment (PISA) released its latest findings. In it, the United States was found to have remained stagnant in its results since 2000 (Schroeder, Scott, Tolson, Huang, & Lee, 2007). Further, other countries that have participated in the program since 2000, like the Czech Republic, have moved ahead of the US, and still other countries that have just recently entered the program, like Vietnam, have started out ahead of the US (Schroeder et al., 2007). Further, at one point, American students at schools where less than 10% of the population lived poverty performed better than any country in the world. However, today, they are sixth (Carnoy & Rothstein, 2013).

Current research in comparing fifth grade math teacher quality to student math achievement in eighth grade or any grade level for that matter is non-existent. Having said that, research comparing inputs to the future outputs of student achievement, including with the use of the ECLS-K data, set does exist. One study showed that students' achievement on standardized tests was related to their prior knowledge and previously-learned basic skills (Todd & Wolpin, 2003).

Claessens, Duncan, and Engel (2008) used the 1998 ECLS-K data set to investigate how kindergarten skills effect fifth grade math achievement. In their research, they found that there was a relationship between academic skills learned in kindergarten and fifth grade achievement. In looking at specific regression results, they found a correlation between:

- kindergarten-level math and fifth grade math scores ($r = 0.63$),
- kindergarten-level English and fifth grade English scores ($r = 0.50$),

- kindergarten-level math and fifth grade English ($r = 0.60$),
- kindergarten-level English and fifth grade math ($r = 0.47$).

Education Production Function Literature

The idea of an education production function has gained notoriety in the research around teacher effectiveness (Felch, Song, & Smith, 2010). In the context of current education policy, a form of a production function and value-added metrics have been debated among policy makers as an effective way to evaluate teachers. The theoretical framework of this study viewed the work through the lens of a production function in which a series of inputs lead to effective outputs.

Samuel Bowles (1970) was largely credited with coming up with the idea of the education production function. Bowles described the idea of a production function, "education or not as the maximum level of outcome possible from an alternate combination of inputs" (p. 13). It summarizes the technical relationship between and among inputs and outputs. As he described it, applied in its traditional form, knowledge of an educational production function is essential to efficient resource planning. Like a mathematical function, certain variables are inputted into a formula of some sort. When inputted into that formula, a specific output or outputs are produced.

The output, as in this study, focuses on student achievement. While a large body of research has measured other outputs such as economic output (Hanushek, 1981) and analyzing school expenditures (Pritchett & Filmer, 1999), such research is beyond the scope of this review. With that, Hanushek (1981, 2011) focused a great deal of his research around the idea of how certain inputs affect the achievement outputs of schools. Other authors such as Krueger (1999) and Murnane and Phillips (1981) did similar production function studies linking predictors to outputs.

The variability in the research on education production function tends to be focused on the inputs that affect academic achievement. This dissertation study focused on the relationship between teacher inputs in previous years and future academic achievement. Other research focused on other types of inputs and education. Hanushek (1981, 2011) did a series of other studies with other inputs, for example, looking at the money schools have, indicators of school quality, and comparisons of teacher characteristics such as years of experience.

Because this study essentially looked at three large inputs—fifth-grade math teacher characteristics, fifth-grade math teacher professional development, and fifth-grade math teacher characteristics—and connected them to the relationship of eighth-grade student math outputs, looking at this study through the lens of an education production function is appropriate.

Conclusion

When looking at the research through the lens of an education production function, it was expected that fifth-grade teacher quality inputs would affect student learning in eighth grade. Specifically, certain practices such as homogenous grouping, the use of technology, and direct instruction showed positive effects on student learning. Experience matters to some degree (Darling-Hammond et al., 2005), as does content and pedagogical knowledge. Finally, professional development provides teachers an opportunity to grow in both content knowledge as well as teaching practices (Ball, 1997).

It is clear there is an interactive relationship between the three. The teacher background inputs can be seen as the preparation in which a teacher comes to their practice. Professional development is a method by which teachers improve their practice and can largely get better in terms of implementing new strategies. The use of certain teaching practices is certainly a combination of both, where teachers tend to favor that which was in their background, whereas professional development is the lever that moves them toward greater effectiveness and will help student learning the most.

Further, it is clear that a drop in achievement occurs somewhere between fifth and eighth grade (Rockoff & Lockwood, 2010; West & Schwerdt, 2012). While this study is limited in that data from sixth and seventh grades were not available, as well as inputs beyond teaching, the fact is teacher inputs matter, fifth through eighth grade placement matters, and professional development matters. The relationship between a previous teacher and a student's future has value and predictability (West & Schwerdt, 2012).

The research connecting prior learning experiences in previous grades and future achievement is limited. While some research has been published on early years like kindergarten and first grade, none exists for upper elementary and secondary schools. This is in spite of the fact that prior learning experiences do matter for future math success (Hanushek, 2011), and that middle school matters. Beyond this, while the current study does not touch on this specific issue, the relationship between elementary school and high school is also a place of interest for researchers if they can gather relevant data. It is the hope of this author that the study helps provide a contribution to the beginning stages of research on predicting mathematic outcomes.

Finally, it is important to understand the context and connection between social justice and the Common Core math standards. The tradition of social justice argues for educators to produce, at the least, self-empowered citizens, liberated from an oppressive mindset. While the habits of mind that the standards of mathematical practice promote are in line with this ideal, to say they go far enough to achieve the vision of social justice would be inaccurate. These standards of practice do however provide a structure and accessibility to classical mathematics that was not common in the tradition of American math classrooms. This is crucial, and will lead more students to be better critical thinkers, and more mathematically fluent: thus more participatory citizens. To fully immerse students into the ideas of social justice, community, and critical thinking, mathematics must be incorporated into the curriculum at a local level. This requires the work of teachers, department leaders, and school leaders to design lessons, units, and curricula that integrate high quality mathematics within the context of social and political circumstances.

CHAPTER THREE

METHODOLOGY

Introduction

As described in Chapter One, the purpose of this study was to analyze which fifth-grade teacher math inputs were the most important predictors of future math outcomes of eighth-grade students as measured by standardized assessments. The research questions were as follows:

1. To what extent do fifth-grade teacher background and experience predict eighth-grade student math performance?
2. To what extent do fifth-grade teacher professional development hours in mathematics and perception of the quality of their PD predict eighth-grade student math performance?
3. To what extent do fifth-grade teacher math instructional practices predict eighth-grade student math performance?

The theoretical framework upon which this study was based is an education production function. In looking at a study through the lens of an education production function, a trend in the research emerged in using regression analysis to answer certain questions.

Data Source

Data for this dissertation came from ECLS-K data set released by the National Center on Education Statistics (1998-2007). Since the organization of this data set, a subsequent set has been released, ECLS-B, that focuses on early life experiences. Its sponsor is the United States Department of Education. The original data set followed the progress of over 21,260 students during the course of their K-8 academic careers and gathered data enabling an analysis of the relationships among a wide array of variables associated with each student. This study looked at the academic achievement of the 5,313 eighth graders who were scored at the end of the study. The data used are from the third (2002), fifth (2004), and eighth grade (2007) waves of the Early Childhood Longitudinal Study-Kindergarten.

The relationship between fifth-grade teacher math inputs and eighth-grade math achievement was investigated. The dependent variable used in this study was the eighth-grade standardized scores (*t*-scores) on a direct cognitive assessment of students' mathematical performance (ECLS-K variable MATHC7RC4). The *t*-scores provided a more stable measurement compared to the raw scores students achieved on the test (MATHC7RC5), which were also available. There were 27 independent variables around fifth-grade teachers of mathematics used in this study (See Appendix A.). These variables fell into three broad categories: teacher background, teacher perception of professional development, and teaching practices.

Analysis Sample Group

The sample selection for the ECLS-K was based on a probability sampling design that had three stages to ensure a data set that was a national representation of children attending kindergarten in 1998–99. The design was to model information around five-year-old children provided in the 1990 census data.

Primary sampling units (PSU) were created to ensure this. The first, and primary, sampling unit was a geographic area consisting of counties or groups of counties. The second stage sampling unit consisted of schools within the PSU. The third stage unit represents the children within those schools. The geographic areas were largely based on 1990 census data to create a sample size that was representative of what the country's population would look like during the decade.

The initial ECLS-K design study recommended sampling 23,500 children in approximately 1,000 kindergarten programs from 100 primary sampling units. The structure of the study oversampled and under-sampled certain demographic groups, such as Asian/Pacific Islanders and special education students, to get a sample that was both more reflective of national demographic trends and more descriptively meaningful data. A large initial sample of children had been reduced over time due to subsampling moving from their schools, and nonresponses. The number of kindergarten students initially sampled was 21,260. By the time the students sampled made it to fifth grade, the final sample size for math students was 11,368 students. Of those students' teachers, approximately half of the teachers were asked to complete math questionnaires about student performance. The survey was completed by 5,339 teachers. The other half of the teachers completed a science performance survey. For eighth-grade students used in this study, the final sample size was 9,615. The number of sampled eighth graders whose teachers filled out the survey instrument in fifth grade was 4,243.

Data Collection Instruments

The ECLS-K collected data directly from children and their parents, teachers, and schools in the fall and spring of kindergarten (1998), the fall and spring of first grade (1999), the spring of third grade (2002), the spring of fifth grade (2004), and the spring of eighth grade (2007). This study used data collected during students' fifth grade year in the fall of 2003 and students' eighth grade year in spring of 2007.

In the fifth grade year, two separate surveys were given to teachers: a general teacher information survey and a math teacher survey. In the fifth grade teacher information survey, 42 questions were provided on a variety of topics from age, race, gender, to perceptions of school leadership and culture. For this study, the questions around teacher backgrounds and teacher professional development came from this survey. In the fifth-grade math teacher survey, twenty-three questions were asked on everything from how teachers group students, to the textbook used, to the time spent doing procedural tasks such as grading. The variables on teacher practices came from this survey. In all, 27 questions were used in this study and those made up the specific variables for this study. The results of these questions were collected and sorted by the sponsors of the study. The National Council for Education Statistics (NCES) made the information available.

Of the questions, 21 of the 27 questions were on a Likert-scale rating from one to five. Five of the questions involving the background of the teacher were yes and no questions. In one question, on the number of hours of PD, teachers were asked to write in the number of hours they attended PD. Scores were coded where higher values indicated stronger relationships.

For both ECLS-K fifth and eighth grade data collection, self-administered questionnaires were used to gather information from teachers, school administrators, and children. Schools were contacted to set times by researchers to conduct the child assessments, link children to teachers, identify children who had withdrawn from the school, and obtain locating information about their new schools. Spring data collection included the direct child assessments and collection of child, teacher, and school questionnaires. Student assessments were timed and group-administered during the school day. For this study, data from the fifth-grade teachers' general and math surveys are used as are eighth-grade student assessment data.

Notices and follow-up phone calls were made to families involved in the study. Fifth-grade student level teacher data were collected in the spring of 2004 using written questionnaires. Approximately half of the teachers completed math surveys about individual students (mathematics: n = 5,339). Fifth-grade student cognitive data were collected in February through June of 2004 using computer assisted personal interviewing (CAPI) and processed by Educational Testing Services (ETS).

Data collection proceeded in the eighth grade year as before, with appropriate permissions and training for data collection field staff in place. Data from the eighth-grade round included test scores (n = 4,243). Tests were mailed to and processed by ETS.

It is important to note how statistics were collected for this study. For the descriptive statistics, each survey question was evaluated based on the number of surveys that were completed. Those who were surveyed and their data verified were included in the sample size. However, for the regression analysis, the sample size was different. That sample included only those students where the survey was completed by their fifth-grade teacher and whose eighth-grade math achievement results were recorded.

Missing Data

The two main causes of missing data in the ECLS-K were family movement and nonresponse. Of the nationally representative sample of kindergarteners, the ECLS-K followed all of the children who remained in the same school, but only followed a subsample of children who transferred schools in first grade, third grade, and fifth grade. When new data were needed to be collected after first grade, third grade, fifth grade, and eighth grade, each child was labeled in one of three ways: gone and not targeted for follow-up, moved and targeted for follow-up, or stayed in the same school. Those who were not found were considered "non-responders." Some of the stayers and flagged movers at each time point became non-responders or individuals who returned only partially completed surveys.

Variables and Assessment

The following fifth-grade teacher inputs will be analyzed: teacher background, professional development, and self-reported instructional practices. Within these three inputs, different questions were used to gather information.

Teacher Background

Eight questions from the survey instrument were used to investigate fifth-grade math instructors.

Years of experience. Questions 32 and 33 involving years as a school teacher on the Spring 2004 fifth-grade Teacher-Level Questionnaire were conducted. The questions were as follows:

- Counting this school year, how many years have you been a school teacher, including part-time teaching?
- Counting this school year, how many years have you taught this grade, including part-time teaching?

Level of education. Questions 35, 36f, 36g, 37f, and 37g on the Spring 2004 fifth-grade Teacher-Level Questionnaire were conducted. These questions involve the level of academic preparation teachers had before their 2007 teaching assignment.

- What is the highest level of education you have completed?

- If you have an associate's or bachelor's degree, indicate your undergraduate major field of study. (Mathematics)
- If you have an associate's or bachelor's degree, indicate your undergraduate major field of study. (Mathematics Education)
- If you have a graduate degree, indicate your undergraduate major field of study. (Mathematics)
- If you have an associate's or bachelor's degree, indicate your undergraduate major field of study. (Math Education)

Instructional Practices

To measure this variable, the following 17 questions were used:

- In a typical day, how much time do the children in this child's mathematics class spend in the following activities:
    - Teacher-directed whole class activities?
    - Teacher-directed individual activities?
    - Child-selected activities?
    - Children working collaboratively in heterogeneous groups (not grouped by ability)?
- How often do you divide this class into instructional groups, based on achievement groups, based on achievement levels, for mathematics activities or lessons?
- On days when you use achievement grouping, how many mathematics groups does this class have?

- How often does the child identified on the cover of this questionnaire engage in the following as part of mathematics instruction:
    - Solve mathematics problems from textbooks or worksheets?
    - Solve mathematics problems from the blackboard or overhead?
    - Solve mathematics problems in small groups with a partner?
    - Work with measuring instruments e.g., rulers?
    - Work with manipulatives?
    - Use a calculator?
    - Take mathematics tests/quizzes?
    - Write a few sentences about how to solve a mathematics problem?
    - Discuss solutions to mathematics problems with other children?
    - Work and discuss mathematics problems that reflect real-life situations?
    - Use a computer for math?
    - Use visual representatives (e.g., diagrams, tables, models)?

Professional Development

To investigate this relationship, the following two questions from the Spring 2004 Fifth Grade Teacher-Level Questionnaire were conducted (See Appendix A.):

- During the past year, how many hours in total have you spent in staff development workshops or seminars in the following content areas? Write in the number of hours spent in each content area.
- Overall, how useful were these activities to you? Mathematics or teaching of mathematics?

Direct Child Assessment

The ECLS-K cognitive assessment measured children's cognitive status in eighth grade as well as kindergarten, first grade, third grade, and fifth grade. A team consisting of item developers from Educational Testing Service (ETS), elementary school curriculum and content area specialists, and elementary school teachers reviewed and selected a pool of assessment items from existing published tests. The team also developed new assessment items that could be used to measure children's cognitive achievement longitudinally. This dissertation focused on the eighth-grade assessment. Due to copyright restrictions, the exam was not available for public view. The eighth-grade exam measured the following math domains:

- number sense,
- properties and operations,
- measurement,
- geometry and spatial sense,
- data analysis, statistics, and probability, and
- patterns, algebra, and functions.

Prior to administering the cognitive batteries, the ECLS-K assessors administered a brief language screening, the Oral Language Development Scale (OLDS), to children identified by the school staff as coming from a family that spoke a language other than English in the home. The OLDS assessment measured whether children understood English well enough to take the ECLS-K direct assessments in English. Children who passed the OLDS then participated in the full ECLS-K cognitive battery (math, language arts, and science exams) in English. Those who did not pass the OLDS participated in a reduced version of the ECLS-K battery, which did not include the English versions of the cognitive assessments. Assessors typically conducted the cognitive assessments in a school classroom or library. The tests were computerized and were semi-adaptive (i.e., a computer generates questions based on algorithms). Scores were recorded and input into the ECLS-K database. For this study, the scaled *t*-score was looked at as opposed to the raw total score.

Statistical Procedures

When testing these variables, three different types of statistics were run. Descriptive statistics were gathered on each predictor and the assessment in order to analyze trends in the data set. Correlations were run to analyze the following variables to see if the measurements co-vary:

- Fifth-grade professional development predictors and eighth-grade test scores
- Fifth-grade teacher characteristic predictors and eighth-grade test scores
- Fifth-grade teacher practices predictors and eighth-grade test scores

The table in Appendix A lays out the predictors being analyzed. These correlations were done to investigate a relationship between each predictor and student achievement.

Further, simple multiple regression analysis was conducted. This looked at the following:

- All predictors (teacher characteristics, practices, and PD) as composite variables in relationship with the outcomes of the eighth grade cognitive skills assessment.

The primary purpose of the regression was to investigate whether there was a directional relationship between the fifth-grade predictors and eighth-grade test scores rather than a non-causal, relationship between predictor and achievement.

There were multiple input variables involved and a single output variable, in this case, student's average score on the eighth-grade direct child assessment. The regression analysis was conducted to look at what production functions existed between fifth-grade teacher math inputs and eighth-grade math outputs. The tests were run using the data set provided by ECLS-K.

CHAPTER FOUR

RESULTS

Purpose

The purpose of this study was to explore and analyze which fifth-grade teacher mathematical inputs were the most important predictors of future achievement for eighth-grade mathematics students in classrooms as measured by cognitive examination test scores. The following research questions guided this quantitative study of the predictors of eighth-grade math success:

1. To what extent do fifth-grade teacher background and experience predict eighth-grade student math performance?
2. To what extent do fifth-grade teacher professional development hours in mathematics and perception of the quality of their PD predict eighth-grade student math performance?
3. To what extent do fifth-grade teacher math instructional practices predict eighth-grade student math performance?

Review Procedures

In answering the questions, several statistical tests were run:

- descriptive statistics, including the frequency of responses from each predictor by a given survey;
- the correlation between each predictor and eighth-grade math achievement;

- a regression between each group of predictors (perception and time spent in professional development, teacher background, and instructional practices) and eighth-grade achievement;
- all predictors used in the study and eighth-grade math achievement.

The frequency statistics were important as they provided a possible opportunity to see trends in teacher practices. The correlation statistics were important for showing a positive or negative relationship between each predictor and eighth-grade math achievement. The mean and standard deviation were important because they showed the central tendencies of each predictor. The regression analysis was important because it provided clear evidence between how much each group of predictors (as well as collectively) was related to eighth-grade math achievement.

In the fifth grade, the sample of teachers were asked to fill out either a science or math survey of what their students do in class, along with a teacher survey that asks questions about their work. This study looked at the mathematics achievement of the 5,313 students whose teachers completed both the general ECLS-K fifth-grade teacher survey and the ECLS-K math survey and went on to take a math achievement test in eighth grade. Depending on whether the teacher completed every question on both surveys, the results of every statistical test may vary. Further, when the regressions occurred, only students whose teachers completed both surveys and the student themselves who also took the math achievement test were included in that part of the sample.

Data from this dissertation came from the ECLS-K data set released by the National Center on Education Statistics (1998-2007). The data were presorted. Twenty-seven predictors were analyzed in looking at the relationship between math inputs and math achievement. In the current study, much of the data on teacher demographics were withheld. Race and gender of fifth-grade teacher participants were inaccessible in the public data set.

Frequency and descriptive statistics, a correlation between each predictor and eighth-grade math outputs, and a regression analysis between each category of predictor and eighth grade math outcomes were run.

The number of students in each analyses varied depending on the number of responses. In the descriptive and frequency analyses, every fifth-grade student whose teacher took the teacher and math teacher surveys and answered the appropriate questions were counted. For the correlation and regression, the same students were counted, but only counted in those statistics if they took the eighth-grade cognitive skills math assessment used to measure academic achievement (n = 3,145).

Question 1

Appendix B shows the frequency of responses to each question. A trend emerged where responses tended towards a specific response. This indicated that teachers in this data set typically were set in certain practices. For example:

- 64.3% of respondents reported spending a half hour or less/no time having children work in heterogeneous groups. Another 14.5% of respondents reported spending no time putting students in heterogeneous groups;
- 52.1% of respondents reported spending no time on child-selected activities in mathematics. Another 43.4% reported spending a half hour or less in class on child-selected activities;

- 53.5% of respondents reported children taking math tests or quizzes once or twice a month. Another 40.6% report taking a test or quiz once or twice a week;
- 85.1% of teacher reported solving math problems from textbooks or worksheets almost every day.

Tables 1 and 2 show the sample means and standard deviation for each instructional practice predictor. In Table 1, the responses were coded as the frequency a practice is used per week: 1 – no time, 2 – half-hour or less, 3 –about one hour, 4 – about two hours, and 5 – three hours or more. In Table 2, the responses are coded as follows: 4 – almost every day, 3 – once or twice a week, 2 – once or twice a month, and 1 – never or hardly ever.

Table 1
Descriptive Statistics – Instructional Practices

Predictor	*M*	*SD*
Teacher-directed Whole-Class Math Instruction	2.54	0.885
Teacher-directed Small Group Instruction	2.05	0.668
Teacher-directed Individual Instruction	2.03	0.661
Child-selected Activities Math	1.53	0.600
Heterogeneous Grouping Math	2.13	0.741

In Table 1, child selected activities ($M = 1.53$) tended to be used, on average, less than the other activities. The other activities all had mean scores above indicating each practice is generally used by a teacher at least once a week. In Table 2, the practice that had the highest mean score was using a textbook ($M = 3.82$) indicating textbooks were used very frequently as was problem solving ($M = 3.57$), doing real life math problems ($M = 3.09$), and doing math in groups ($M = 3.12$). Also of note is the high deviation for the use of a calculator ($SD = 0.974$). The correlation statistics are given in Table 3.

Table 2

Frequency of Instructional Practice: Descriptives

Predictor	*M*	*SD*
Frequency Students Use Textbooks	3.82	0.470
Frequency Students Solve Problems	3.57	0.699
Frequency Students Do Math In Groups	3.12	0.839
Frequency Students Use Measuring Instruments	2.43	0.711
Frequency Using Manipulatives	2.38	0.815
Frequency Using a Calculator	2.13	0.974
Frequency Child Takes Math Tests	2.61	0.593
Frequency Child Writes Math Solutions	2.52	0.928
Frequency Child Discusses Math Problems	3.13	0.884
Frequency Child Does Real-life Math Problems	3.09	0.798
Frequency Child Uses Computer for Mathematics	1.80	0.914
Frequency Child Uses Visual Representations	2.99	0.746

Table 3

Correlation – Fifth-Grade Mathematics Teaching Practices on Eighth-Grade Achievement

Predictor	*r*
Teacher-directed Whole-Class Math Instruction	-0.017
Teacher-directed Small Group Instruction	-0.035
Teacher-directed Individual Instruction	-0.013
Child-selected Activities Math	0.004
Heterogeneous Grouping Math	-0.005
Frequency Students Use Textbooks	0.024
Frequency Students Solve Problems	0.026
Frequency Students Do Math In Groups	0.014
Frequency Students Use Measuring Instruments	0.031
Frequency Using Manipulatives	-0.064*
Frequency Using a Calculator	0.073*
Frequency Child Takes Math Tests	-0.009
Frequency Child Writes Math Solutions	0.900*
Frequency Child Discusses Math Problems	0.126*
Frequency Child Does Real-life Math Problems	0.045*
Frequency Child Uses Computer for Mathematics	-0.033*
Frequency Child Uses Visual Representations	0.005

* $p < .05$ *r* = correlation value

The results of Table 3 show the following:

- Based on the results of the study, frequency using a calculator was positively related to eighth-grade math achievement, $r = 0.073$ $p < .05$.
- Based on the results of the study, frequency using manipulatives was negatively related to eighth-grade math achievement, $r = -0.064$ $p < .05$.
- Based on the results of the study, frequency of the child writing math solutions was positively related to eighth-grade math achievement, $r = 0.090$ $p < .05$.
- Based on the results of the study, the frequency of a child discussing math problems was positively related to eighth-grade math achievement, $r = 0.126$ $p < .05$.

- Based on the results of the study, the frequency of using real-life math problems was positively related to eighth-grade math achievement, $r = 0.045$ $p < .05$.
- Based on the results of the study, the frequency a child uses a computer was negatively related to eighth-grade math achievement, $r = -0.033$ $p < .05$.

A multiple linear regression was calculated to predict eighth-grade mathematics achievement based on fifth-grade math teachers' teaching practices. A regression equation was found: (F (17, 3953) = 4.059, p <.001), with an $R^2 = 0.049$. The predicted impact on student achievement is presented in Table 4 as follows:

Table 4
Regression Coefficients: Fifth-Grade Math Teacher Practices and Eighth-Grade Math Outputs

Predictor (n = 2,369)	B	*SE B*	β
Frequency Students Use Textbooks	0.319	0.437	0.016
Frequency Students Solve Problems	0.192	0.291	0.014
Frequency Students Do Math In Groups	-0.794	0.308	-0.064
Frequency Students Use Measuring Instruments	1.310**	0.850	0.23**
Frequency Using Manipulatives	-1.530	0.340	0.350
Frequency Using a Calculator	0.782**	1.920	0.56**
Frequency Child Takes Math Tests	-0.373	0.337	-0.023
Frequency Child Writes Math Solutions	1.110**	1.330	1.498**
Frequency Child Discusses Math Problems	1.590**	0.43**	0.358**
Frequency Child Does Real-life Math Problems	-0.572	0.336	-0.045
Frequency Child Uses Computer for Mathematics	-0.299*	0.227*	-0.028*
Frequency Child Uses Visual Representations	-0.205	0.312	-0.016
Time in a Math Workshop	-0.013	0.009	-0.031
Usefulness of the Professional Development	-0.099	0.258	-0.008

* p<.05 ** p<.01

Frequency doing math in groups ($p < .01$), frequency using measuring instruments ($p < .01$), frequency using a calculator ($p < .01$), frequency using manipulatives ($p <.01$), frequency child writes math solutions ($p < .01$), frequency child discusses math problems ($p < .01$), and frequency child uses computers to do math ($p < .05$) all showed a very small prediction value. Fifth grade teaching practices as a whole had a small impact on eighth grade outcomes ($p < .01$).

Question 2

Appendix C shows the frequency of response to each question. The table shows that teachers on average spent more than seven hours over the course of a year in a professional development workshop (38.1%). Almost 29% of the population did not spend any time in PD at all.

Table 5 shows the descriptive statistics for these variables and Table 6 shows the correlation statistics. For time in a workshop, teachers indicated the number of approximate hours they spent. For the usefulness of a PD, they coded 1 not useful at all, 2 slightly useful, 3 moderately useful, or 4 very useful. Based on the results, teachers spent, on average, over nine hours in a math professional development workshop and agreed as a whole that the time was useful. Based on the results of this study, time in a math workshop (r =-0.033) did not have a significant relationship to eighth grade outcomes. Usefulness of the professional development (r = -0.017) did not have a relationship to eighth grade outcomes.

Table 5
Descriptives: Time in Math Professional Development and Its Usefulness

Predictor	*M*	*SD*
Time in a Math Workshop	9.85	19.607
Usefulness of the PD	3.18	0.775

Table 6
Correlation Table: Perception and Time Spent in Math Professional Development and Eighth Grade Achievement in Math

Predictor	*r*
Time in a Math Workshop	-0.033
Usefulness of the PD	-0.017

A multiple linear regression was calculated to predict eighth-grade mathematics achievement based on fifth-grade math teachers' time spent and perception of professional development. A regression equation was found, (F (2, 5187) = 4.059, $p < 0.001$), with an R^2 = 0.002. The results are presented in Table 7.

Table 7
Regression Coefficients: Fifth-Grade Teacher Input and Eighth-Grade Outputs

Predictor (n = 2,369)	B	*SE B*	β
Time in a Math Workshop	-0.013	0.009	-0.031
Usefulness of the Professional Development	-0.099	0.258	-0.008

Neither time spent in a math workshop nor the usefulness of the math workshop were significant predictors.

Question 3

Appendix D shows the frequency of response to each question. The descriptives showed that over three-quarters of the teachers surveyed did not have an undergraduate or graduate degree in mathematics. Over half of teachers did not have a certification in any sort of mathematics. Table 8, Table 9, Table 10, and Table 11 show the correlation and descriptive statistics.

Table 8
Teacher Background Yes/No Responses

Predictor	*M*	*SD*
Undergraduate Math Education	1.95	0.222
Grad Degree in Mathematics	n/a	n/a
Certification in Elementary Mathematics	1.64	0.479
Certification in Secondary Mathematics	1.91	0.290

Table 9:
Level of Education

Predictor	*M*	*SD*
Highest Level of Education a Teacher Achieved	2.23	0.918
Number of Classes about Teachers Teaching Mathematics	2.66	1.812

Table 10:
Free Response Numerical Response: Teacher Background

Predictor	*M*	*SD*
Years Taught their Given Grade	7.6	6.897
Number of Years Been a School Teacher	14.7	10.457

Table 11
Correlation: Fifth-Grade Math Teacher Background and Eighth-Grade Achievement in Mathematics

Predictor	*r*
Highest Level of Education a teacher Achieved	0.0480*
Undergraduate Math Education	-0.0009
Grad Degree in Mathematics	n/a
Certification in Elementary Mathematics	-0.0450
Certification in Secondary Mathematics	-0.0240
Number of Classes about Teachers Teaching Mathematics	0.0090
Years Taught their Given Grade	0.0540*
Number of Years Been a School Teacher	0.0700

*$p < .05$

Years taught in their given grade showed a small correlation value ($r = 0.054$) as did the highest level of education a teacher received ($r = 0.048$).

A multiple linear regression was calculated to predict eighth-grade mathematics achievement based on fifth-grade math teacher background. A regression equation was found. (F (10, 4690) = 4.059, p <0.01), with an $R^2 = 0.002$.

Table 12

Regression Coefficients: Fifth-Grade Teacher Background and Eighth-Grade Outputs

Predictor (n = 2,369)	B	*SE B*	β
Highest Level of Education a Teacher Achieved	0.227	0.225	0.022
Undergraduate Math Education	-0.081	0.895	-0.002
Grad Degree in Mathematics	n/a	n/a	n/a
Certification in Elementary Mathematics	0.712	0.425	0.036
Certification in Secondary Mathematics	0.637	0.714	0.019
Number of Classes about Teachers Teaching Mathematics	0.021	0.115	0.004
Years Taught their Given Grade	0.003	0.041	0.002
Number of Years Been a School Teacher	0.047*	0.028*	0.052*

*p<0.05

Only the number of years been a school teacher was a small, significant predictor of academic achievement ($p < .05$). All others were not significant predictors of academic achievement.

Overall Regression

A simple regression analysis was done. All 27 of the predictors were entered with the objective being to predict the dependent variable of academic achievement. The objective was to determine the degree with which the dependent variable (D.V.) by each of the independent variables (I.V.), and then by combinations of the I.V. grouped by categories: teacher background, professional development, and teaching practices. The regression had two scores, a standardized and a non-standardized score. The standardized error is also presented.

In looking at the regression analysis, 22 of the 27 predictors did not produce a result that was statistically significant (See Table 13.).

Table 13
Regression Coefficients: Fifth-Grade Teacher Input and Eight- Grade Outputs

Predictor (n = 2,369)	B	*SE B*	β
Highest Level of Education a Teacher Achieved	0.227	0.225	0.022
Undergraduate Math Education	-0.081	0.895	-0.002
Grad Degree in Mathematics	n/a	n/a	n/a
Certification in Elementary Mathematics	0.712	0.425	0.036
Certification in Secondary Mathematics	0.637	0.714	0.019
Number of Classes about Teachers Teaching Mathematics	0.021	0.115	0.004
Years Taught their Given Grade	0.003	0.041	0.002
Number of Years Been a School Teacher	0.047	0.028	0.052
Teacher-directed Whole-Class Math Instruction	0.038**	0.269	0.004
Teacher-directed Small Group Instruction	-0.343	0.386	-0.023
Teacher-directed Individual Instruction	-0.121	0.343	-0.008
Child-selected Activities Math	0.665	0.36	0.041
Heterogeneous Grouping Math	-0.003	0.326	0
Frequency Students Use Textbooks	0.319	0.437	0.016
Frequency Students Solve Problems	0.192	0.291	0.014
Frequency Students Do Math In Groups	-0.794	0.308	-0.064
Frequency Students Use Measuring Instruments	1.31**	0.85	0.23**
Frequency Using Manipulatives	-1.53	0.34	0.35
Frequency Using a Calculator	0.782**	1.92	0.56**
Frequency Child Takes Math Tests	-0.373	0.337	-0.023
Frequency Child Writes Math Solutions	1.11**	1.33	1.498**
Frequency Child Discusses Math Problems	1.59	0.43	0.358
Frequency Child Does Real-life Math Problems	-0.572	0.336	-0.045
Frequency Child Uses Computer for Mathematics	-0.299	0.227	-0.028
Frequency Child Uses Visual Representations	-0.205	0.312	-0.016
Time in a Math Workshop	-0.013	0.009	-0.031
Usefulness of the Professional Development	-0.099	0.258	-0.008
Overall	43.159	2.623	

** $p < 0.05$, * $p < .01$
Note. B: Unstandardized coefficient, *SE B*: standard error, β: Standardized coefficient

Five predictors presented significant values. The predictors had five of the six highest correlation values. Those predictors are in Table 14.

Table 14
Summary of Simple Regression for Predicting the Impact of Fifth-Grade Teacher Inputs on Eighth-Grade Achievement

Variable (n = 2,369)	B	*SE B*	β
Frequency Child Discusses Math Problems	1.59**	0.43	.358**
Frequency Child Writes Math Solutions	1.11**	1.33	1.498**
Frequency Using Measuring Instruments	1.31**	0.85	.23**
Frequency Using Manipulatives	-1.53*	0.34	.35*
Frequency Using Calculator	.782*	1.92	.56*

*$p < 0.05$, **$p < 0.01$

In Table 15, an overall regression was done to analyze the relationship between fifth-grade teacher math inputs and eighth-grade math achievement.

Table 15
Summary of Simple Regression for Predicting the Impact of Fifth-Grade Teacher Inputs on Eighth-Grade Achievement Sorted by Categories

Variable (n = 2,369)	B	*SE B*	β
Professional Development	.04**	0	0.001**
Teacher Background	.09**	9.48	0.012**
Teaching Practices	0.22**	0.05	0.051**
Combined	0.25**	0.04	0.062**

**$p < 0.01$

A regression equation was found. (F (27, 2369) = 5.827, p <0.001), with an R^2 = 0.062. In comparing the β value to the standard error, the overall β value was 0.052. The standard error was 9.33 on a test, which the maximum possible score was 87.1.

This regression results showed some significant findings. For one, what teachers did in the classroom in fifth grade did have a small affect on eighth-grade math achievement. As stated earlier, many of the variables used for this study showed both a low coefficient value. Having said that, the more students wrote and talked about math in a classroom in fifth grade, the more they appeared to achieve in eighth-grade mathematics. Also, the use of a calculator and measuring instruments both had smaller, but significant relationships to eighth-grade math achievement based on coefficient values.

Professional development for fifth-grade math teachers appeared to have little affect on achievement. For both questions the coefficient values are very small.

Teacher background had a very small impact as well. While the correlational value of years in a classroom and the highest level of education showed significance, when put through a regression, all of the predictors had an insignificant effect. Those two predictors had moderately positive coefficient values ($\beta = 0.42$; $\beta = 0.34$) but high *p*-values ($p > 0.05$).

Summary

When looking at fifth-grade teachers' backgrounds on eighth-grade math achievement, there was little to no relationship between the two, except for a relationship between the number of years of a fifth-grade teachers' experience and eighth-grade math achievement. Time spent and perceptions of professional development had no significant relationship to eighth-grade math achievement. Many fifth-grade teaching practices, both collectively and individually, had a very small positive relationship with eighth-grade math outcomes. Taken as a whole, fifth-grade teacher math inputs in this study seemed to explain but a small part of the variance regarding eighth-grade math achievement.

CHAPTER FIVE

CONCLUSIONS

Purpose

The purpose of this study was to explore and analyze which fifth-grade teacher math inputs were the most important predictors of future achievement of eighth-grade math students in classrooms as measured by cognitive examination test scores. The following research questions guided this quantitative study of the predictors of eighth-grade math success:

1. To what extent do fifth-grade teacher background and experience predict eighth-grade student math performance?
2. To what extent do fifth-grade teacher professional development (PD) hours in mathematics and perception of the quality of their PD predict eighth-grade student math performance?
3. To what extent do fifth-grade teacher math instructional practices predict eighth-grade student math performance?

Summary of the Regression Results

The theoretical framework of this study looked through the lens of an education production function. By taking this approach, a trend in the research emerged in using regression analysis to answer the research questions.

As a whole, fifth-grade math teaching practices had some impact, albeit small, on eighth-grade math outcomes. A majority of the teachers surveyed trended toward using certain math practices more frequently than others. Also, specific math practices had positive correlations to eighth-grade math achievement. There were some practices that had negative correlations to eighth-grade math achievement. When looking at a regression analysis, fifth-grade math instructional practices explained 5.2% of the variance of eighth-grade math achievement.

A couple of the more interesting non-findings from the regression results were the fact that years as a school teacher did not show any effect on eighth-grade math achievement nor did small group instruction or hours of professional development. Other studies (Ball, 1997; Tomlinson, 2008) indicated that both small group and number of years matter; however, this study showed little to no effect for these variables.

Frequencies of Specific Practices and Significant Predictors

An interesting residual trend that emerged from the study was the fact that frequency statistics paint a picture of trends in fifth-grade math teaching actions. For a majority of the questions around all three groups of predictors, the responses aggregated around specific practices. For example:

- 64.3% of respondents reported spending a half hour or less grouping students heterogeneously. Another 14.5% did not do it at all;
- 48.7% of respondents did not use computers for math instruction. Another 27.8% used them a half hour or less;
- 49.1% of respondents reported children using visual representations in class once or twice a month. Another 26% said they never or rarely ever use them.

Further, some of the correlations appeared significant, and point to relevance at later grade levels. For example, the following predictors had significant positive correlational value and the highest regression coefficient values:

- teacher-directed small group instruction,

- frequency using a calculator,
- frequency a child discusses math solutions, and
- frequency a child writes out math solutions.

All of these point out practices that are supported by the Common Core Standards of Mathematical Practice. Math Practice Standard Five emphasizes the use of appropriate tools in mathematics. When used appropriately, these tools can deepen students understanding of concepts (National Governors Association, 2013). Further, Math Practice Standard Two is reasoning abstractly and quantitatively. Practice Three emphasizes constructing viable arguments and critiquing the reasoning of others. These standards of math practice (SMPs) are certainly supported by the idea of writing and discussing math solutions in a classroom.

All that being said, these were not among the most frequently used practices in which fifth-grade math teachers engaged:

- Teacher-directed Small Group Instruction—84.3% of teachers spent a half hour or less in this on any given day.
- Frequency using a calculator—64.1% of teachers used calculators at least once/twice a week (or every day).
- Frequency a child discusses math solutions—79% of teachers discussed math solutions with others once or twice a month/never or hardly ever.
- Frequency a child writes out math solutions— 53.9% of teachers wrote but a few sentences about how to solve a math problem.

According to Siegler and Heibert (1999), American math classrooms have a specific tradition to themselves. The tradition includes components looked at in this study:

- Teacher-directed Whole-Group Instruction (Siegler & Hiebert, 1999)—64.5% of teachers spent a half hour or less on this practice in a given day.
- Use of a textbook and worksheets (Siegler & Heibert, 1999)—85.4% of teachers surveyed reported engaging in this practice almost every day.
- Take math tests/quizzes (Siegler & Heibert, 1999)—94.3% of teachers reported using tests or quizzes "once or twice a week" or "once or twice a month".

None of these practices had a significant correlational value to eighth grade math outcomes.

Limitations of the Study

Upon analyzing the results of this study, some shortcomings emerge. For one, the study does not cover sixth- and seventh-grade mathematics. Based on the findings of this study, fifth-grade math inputs had a small impact on eighth-grade math achievement. Therefore, that in itself could lead to the possibility that sixth and seventh grade may potentially have a more significant impact on student math achievement. Because those are grades closer to students' eighth grade level of math, and gaps in knowledge are likely more direct, they may lead to a clearer deficit on specific skills on the eighth-grade math achievement test.

Another limitation to this study was the restricted types of questions that were associated with professional development. Much of the research points to a relationship between the types of professional development teachers receive and any potential shift in their practice (Ball, 1997). When teachers become better at their practice, this usually improves student outcomes (Darling-Hammond, 1999). The questions provided by ECLS-K did not provide a lot of specific information about the mathematical professional development received. For example, information on whether it was teacher or student centered would be valuable. Also, whether or not it was ongoing, or whether or not it was content based and of the teachers' choosing. This sort of information around the kinds of training teachers received was not provided. This in turn, does not give a full picture of how fifth-grade teachers are trained to improve their math instruction. Thus, it does not appear that the PD they received was particularly effective.

Education Production Function

In looking at the study through the education production function, it was clear that the various mathematical inputs collectively had a small collective relationship to mathematical outcomes. Only teacher practices provided any significant correlations between the predictors and the outcomes, and the other two groups of predictors, even when added with each other, did not equal the variance of teacher practices. As a production function, fifth-grade teacher math inputs are likely not the most efficient focus to improve eighth-grade math outputs. Through this lens, an open question remains as to the impact that previous year inputs have on outputs. More specifically, it is fair to ask what specific inputs will maximize the output of achievement for eighth-grade math students.

Recommendation for Practice

The shift to the Common Core State Standards has served as a catalyst for teachers to navigate to more effective practices. While nowhere in the Common Core math standards are teachers told how to teach, built into the standards are dispositional goals that students are to achieve in a classroom that, if done with fidelity, would shift the traditional picture of what an American math classroom looks like. Included are critiquing the reasoning of others, reasoning abstractly and quantitatively, and using appropriate tools. This means shifting to practices such as writing in class, talking about a solution, and using a calculator. This study showed that beyond recruitment and outside professional development, the biggest impact on math achievement comes from the types of pedagogical practices that are used in the classroom. It seems clear that some math instructional practices are more effective than others and could possibly lead to more effective math outcomes. An emphasis on school resources around instructional coaching over other mechanisms for teachers with a focus on shifting teachers' practices is a way to maximize time and space.

The idea of math teacher retention, particularly in the context of this study, is highly important. Some experience leads to higher achievement, as evidence by this study and other research behind it. Beyond that, keeping a teacher at a single school helps build a positive school culture (Brill & McCartney, 2008), helps build familiarity within the community, and helps with continuity of school initiatives. While the recession of the late 2000s took the focus away from the idea of retaining teachers, many school districts and charter management organizations are trying to re-emphasize the idea of keeping teachers in the profession, particularly ones who show promise early in their careers (Brill & McCartney, 2008).

Training on devices that could help move teachers' practice forward with immediacy could be helpful. Trends uncovered in this study included negative correlations between both math manipulatives and computer use. Yet, these practices on their own, when used effectively, are generally thought to improve student learning. Computers over the last 10 to 15 years have become trendy topics in education and a movement has emerged to provide a student-to-computer ratio of one-to-one (Alliance, 2014). The assessment platform for Common Core in every state that adopted it is computer-adapted. Further, the National Council of Teachers of Mathematics, among others, has endorsed the use of manipulatives as a way for students to understand mathematics at a deeper level (Boaler, 2002a). Considering that prior literature indicated the potential benefits of the negative correlation in this study, this could possibly be indicative of a lack of training or pedagogical knowledge of how to use such learning tools more effectively.

Finally, the mathematics education community would be well served in transitioning to Common Core to focus on literacy skills. This study points to the idea that the more students write and talk about math earlier and more frequently, the better their future outcomes are. Those in themselves are largely the byproduct of writing clearly about math and structuring thoughts orally to justify mathematical thinking. These are skills in math education that traditionally are not emphasized. In the movement towards Common Core, such skills, which involve a greater emphasis on student literacy, are vital. Training teachers on math content specific literacy will be an important part of the success of common core moving forward.

Recommendations for Further Research

This study raised several important issues that can be explored with future research. While there is a large body of literature that explains mathematical achievement, this study leaves open the question of what impacts eighth-grade math achievement.

Longitudinal research between professional development and student achievement represents a place where there is a gap in the scholarship. Few will debate that effective professional development can impact the growth of teachers in their practices. Certainly if teachers become more effective, student learning should increase. To find a way to measure precisely what kind of impact there could be, a large data set that surveys the type of professional development that teachers participate in should be compared to student test scores. This study starts such a conversation, but because of the limits of the questions, the data does not provide much with which to work. While there is a significant body of research that exists around professional development and what makes it effective, there is little research that looks at longitudinal data and measures its impact in the context of other inputs.

This study raised several important issues that can be explored with future practice. For one, seeing how sixth- and seventh-grade math inputs affect mathematics outputs in eighth grade is important to thoroughly investigate. One of the large limitations to this study was the fact that only eighth grade was featured in the study. If ECLS-K or another entity had similar data that tracked students throughout middle school, this question could be answered. There seems to be some type of relationship, particularly when it comes to teaching practices, where previously learnings affect student achievement. There is no reason not to believe this is the case in seventh grade or in sixth grade.

In looking at how previous years affect student achievement, taking into consideration information around student demographic information would be an important lens to look through. While the teacher matters, so do other characteristics. Specifically, race and SES matter. There is a large body of research that spells out a relationship between class and achievement (Francis, Skelton, & Read, 2010). Many such as Berliner (2006) believe it is the biggest predictor. It is not a stretch to think class could be a large, primary factor in predicting future achievement. A large limitation is the fact that socio-economic levels were not measured in this study. ECLS-K does not have access to students' precise socio-economic levels. That said, there are other studies that indeed do. Also, while it is a question in the survey, race is also not accessible to the public. While the focus of this study was around teachers' impact on achievement, looking at other factors is important, and looking at how various factors in previous years effect student achievement could be impactful.

While this is a small relationship, the results of this study indicate that further study of specific variables relationships might be worthwhile. For example, the role of writing and talking about solutions showed the highest correlation scores and largest coefficient in the final regression equation of all the predictors studied. Research has shown the power these practices have on student learning (Hiebert, 2013). Further, it is also a large emphasis in the Common Core Standards of Mathematical Practice (2013). To see the relationship between time spent doing these practices as well as the quality of them in future research is warranted considering the current context of the new math standards. Having said that, as Common Core is implemented, a good place for future research is to examine the role that writing and talking about solutions has on the learning of math for students.

More research connecting content strands and future achievement appears worthwhile. While a limited body of research exists that predicts specific blocks of content knowledge with future achievement, the research that exists is compelling. For example, the relationship between fractions and future achievement (Siegler et al., 2012) produces a result that suggests knowledge of fractions trumps socio-economic status in terms of future outcomes. While the topic of fractions is a traditional trouble spot for students, others also exist. Such a study could go a long way for researchers and districts to allocate energy and resources effectively.

One final possibility for future research is the idea of differences in inputs and outputs based upon fifth-grade teacher preparation in math education from schools of education or mathematics departments. There is not much longitudinal data around what actually measures this. However, in academia, there tends to be a tension between pure mathematicians and math educators, specifically around what should be emphasized, pure content or accessibility. To be an effective teacher, high content knowledge and how to convey it makes sense. However, what's being conveyed means nothing if teachers don't understand what trainers or professors are saying. The gathering of initial data would mark the starting point of important possible research.

The Math Teacher and Social Justice

Mathematics and student access to an effective math education is a social justice issue. What resonates from the outcomes of this study is the importance of having effective math teachers throughout the K-12 continuum. Middle school grades do indeed matter. Having effective math teachers in grades five through eight is vital later for American high school students to develop effective mathematical skills. This means being more informed citizens via functioning mathematically at a higher level, and thereby being more competitive in the global economy (Wager & Stinson, 2012).

For American students to climb to produce better results, they need to experience a higher quality experience in a math classroom earlier and more often. For this to happen, teachers need to be better prepared to educate them. New teachers need high-quality participants entering the profession and their preparation needs to be strong. For many in-service teachers, a shift in practice may need to occur. The purpose of the Common Core math standards, endorsed by many social justice math advocates (Wager & Stinson, 2012), potentially provides this necessary shift.

That said, within the context of the transition to the Common Core, effective teaching will not happen overnight, and school leaders and politicians need to be patient. The shift to effective teaching practices takes time, space, and training. Teachers need to be given the training and the space to use effective practices in a meaningful way. School districts and leaders need to prioritize math education and prioritize effective training of teachers in mathematics. They also need to invest in long-term planning beyond a single school year. In order for this to occur, teachers need to feel like they have the space to make this happen.

Summary

Fifth-grade math teacher inputs had a small effect on eighth-grade math achievement. The effects were small and the standard error was high in comparison to the possible scores on assessments. That said, a majority of that effect is to be attributed to teachers' practices. Teaching practices such as writing in mathematics and formal discussion of problems had a positive effect on math outcomes. Other practices such as the use of manipulatives and a computer can have a negative effect, although this necessitates further investigation. This can be hypothesized as an effect from a lack of effective training. Perception and time spent on professional development in math had no impact on student outcomes. Similarly, fifth-grade teacher background had little impact as well. This was largely a reflection of the fact that other factors perhaps had a greater impact, and possibly additional years of schooling might have been more impactful as well.

Among other things, more research should be looked at around professional development and teacher inputs. Little longitudinal research exists looking at the topic. The impact of sixth- and seventh-grade teacher backgrounds might be interesting to look at as well. Also the relationship between specific strands of elementary school content, such as fractions, and future achievement might present a clearer and more direct relationship.

With that, there are teaching practices supported in this study that are also supported in the habits of mind of the Common Core State Standards. Practices such as writing and discussing mathematics are important to emphasize in mathematics classrooms. A closer look at teaching practices in sixth and seventh grade would also be a healthy use of time. Further, teachers in fifth grade need to spend more time using practices that are effective and will drive student learning further and faster. In a past era in American math classrooms, it was permissible to lecture for long stretches of time and do nothing else. Based on research, while lecture and direct instruction are still important mechanisms to student learning, a greater emphasis on other practices will provide a greater output of learning (Siegler et al., 2012). Similarly, because there appears to be a negative relationship between certain inputs and outputs that seem like effectively sound practices (use of a computer and use of manipulatives), understanding why this was not the case in this study is important. This is a place of interest for those who are training teachers: specifically, how to train teachers effectively on the use of such tools and what to avoid when using them.

A residual and important recommendation is around small-group instruction. While teachers frequently have varying definitions of what small-group instruction actually entails, its importance in the Common Core era is vital. In order to have opportunity for all students to have consistently rich discussion in class, a classroom that features small groups is necessary. Small-group instruction gives students opportunity to collaborate and discuss math more frequently and freely than in a whole group setting. It also provides opportunity to go deeper into content and specifically have students be able to compare and contrast ideas with peers. Classroom management structures and effective lesson planning are necessary for small-group instruction to be effective (Darling-Hammond, 1999). When executed effectively, it is a gateway to a classroom of high-level thought (Cohen & Hill, 2000).

Finally, the condition of poverty and its impact on outcomes is a topic that cannot be ignored. While a great deal of emphasis has been placed on teachers and what they can do (they represent the biggest variable a school can directly control), the school cannot control for peer groups, and the culture of a school is multilayered. Similarly, schools have little control over what happens before school and after children return home. The effect of poverty, a big problem, might be the most important piece to fully understanding how fifth-grade math inputs truly affect eighth-grade math outcomes.

APPENDIX A

Survey Items Used for the Study

Category	Survey	Question Number	Code
Professional Development			
During the past year, how many hours in total have you spent in staff development workshops or seminars in the following content areas? WRITE IN THE NUMBER OF HOURS SPENT IN EACH CONTENT AREA.	Teacher Questionnaire	21B(1)	J62MAUSE
Overall, how useful were these activities to you? Mathematics or teaching of mathematics.	Teacher Questionnaire	21B(2)	J62MAWKS
Teacher Background			
Counting this school year, how many years have you been a school teacher, including part-time teaching?	Teacher Questionnaire	32	J62YRSTC
Counting this school year, how many years have you taught this grade, including part-time teaching?	Teacher Questionnaire	33	J62YRSGR
What is the highest level of education you have completed?	Teacher Questionnaire	35	J62HGHST
If you have an associate's or bachelors degree, indicate your undergraduate major field of study. *Mathematics*	Teacher Questionnaire	36g	J62UNDMT
If you have an associate's or bachelors degree, indicate your undergraduate major field of study. *Mathematics Education*	Teacher Questionnaire	36f	J62UNDMT

Category	Survey	Question Number	Code
If you have an graduate degree, indicate your undergraduate major field of study. *Mathematics*	Teacher Questionnaire	36f	J62GRMTE
If you have an associate's or bachelors degree, indicate your undergraduate major field of study. *Mathematics Education*	Teacher Questionnaire	36g	J62CRMAT
Teaching Practices			
In a typical day, how much time do the children in this child's mathematics class spend in the following activities? *Teacher-directed whole class activities*	Math Questionnaire	11a	M6WHLCLS
In a typical day, how much time do the children in this child's mathematics class spend in the following activities? *Teacher-directed small group activities*	Math Questionnaire	11b	M6SMLGRP
In a typical day, how much time do the children in this child's mathematics class spend in the following activities? *Teacher-directed individual activities*	Math Questionnaire	11c	M6INDVDL
In a typical day, how much time do the children in this child's mathematics class spend in the following activities? *Child-selected activities?*	Math Questionnaire	11d	M6CHCLDS
In a typical day, how much time do the children in this child's mathematics class spend in the following activities? *Children working collaboratively in heterogeneous groups (not grouped by ability)?*	Math Questionnaire	11e	M6HETGRP

Category	Survey	Question Number	Code
How often do you divide this class into instructional groups, based on achievement groups, based on achievement levels, for mathematics activities or lessons.	Math Teacher Questionnaire	12	M6DIVMTH
On days when you use achievement grouping, how many mathematics groups does this class have?	Math Teacher Questionnaire	13	M6NUMTH
On days when you use achievement grouping, how many minutes per day is the class usually divided for mathematics activities for lessons?	Math Teacher Questionnaire	14	M6MINMTH
How often does the child identified on the cover of this questionnaire engage in the following as part of mathematics instruction? *Solve mathematics problems from textbooks or worksheets*	Math Teacher Questionnaire	15a	M6TEXTS
How often does the child identified on the cover of this questionnaire engage in the following as part of mathematics instruction? *Solve mathematics problems from the blackboard or overhead*	Math Teacher Questionnaire	15b	M6PROBLM
How often does the child identified on the cover of this questionnaire engage in the following as part of mathematics instruction? *Solve mathematics problems in small groups with a partner*	Math Teacher Questionnaire	15c	M6GRPPTN

Category	Survey	Question Number	Code
How often does the child identified on the cover of this questionnaire engage in the following as part of mathematics instruction? *Work with measuring instruments e.g. rulers*	Math Teacher Questionnaire	15d	M6MSINST
How often does the child identified on the cover of this questionnaire engage in the following as part of mathematics instruction? *Work with manipulatives, e.g., geometric shapes*	Math Teacher Questionnaire	15e	M6MANIPU
How often does the child identified on the cover of this questionnaire engage in the following as part of mathematics instruction? *Use a calculator*	Math Teacher Questionnaire	15f	M6USECAL
How often does the child identified on the cover of this questionnaire engage in the following as part of mathematics instruction? *Take mathematics test/quizzes*	Math Teacher Questionnaire	15g	M6MATEST
How often does the child identified on the cover of this questionnaire engage in the following as part of mathematics instruction? *Write a few sentences about how to solve a mathematics problem*	Math Teacher Questionnaire	15h	M6MWRITE

Category	Survey	Question Number	Code
How often does the child identified on the cover of this questionnaire engage in the following as part of mathematics instruction? *Discuss solutions to mathematics problems with other children*	Math Teacher Questionnaire	15i	M6MDISC

APPENDIX B

Descriptive Statistics: Teaching Practices

How often does the child identified on the cover of this questionnaire engage in the following as part of mathematics instruction?

Solve mathematics problems from textbooks or worksheets

	n = 5,295	%
Almost Every Day	4523	85.4
Once or Twice a Week	663	12.5
Once or Twice a Month	62	1.2
Never or Hardly Ever	47	0.9

Solve mathematics problems from the blackboard or overhead

	n = 5.292	%
Almost Every Day	3510	66.3
Once or Twice a Week	1404	26.5
Once or Twice a Month	245	4.6
Never or Hardly Ever	133	2.5

Solve mathematics problems in small groups or with a partner

	n = 5,291	%
Almost Every Day	306	5.8
Once or Twice a Week	662	12.5
Once or Twice a Month	2411	45.6
Never or Hardly Ever	1910	36.1

Work with measuring instruments, e.g. rulers

	n = 5,290	%
Almost Every Day	378	7.1
Once or Twice a Week	2586	48.9
Once or Twice a Month	2013	38.1
Never or Hardly Ever	313	5.9

Work with measuring instruments, e.g. rulers

	n=5,277	%
Almost Every Day	715	13.5
Once or Twice a Week	2260	42.8
Once or Twice a Month	1885	35.7
Never or Hardly Ever	417	7.9

Use a calculator

	n = 5,280	%
Almost Every Day	1717	32.5
Once or Twice a Week	1668	31.6
Once or Twice a Month	1403	26.6
Never or Hardly Ever	492	9.3

Take math test/quizzes

	n = 5,291	%
Almost Every Day	67	1.3
Once or Twice a Week	2146	40.6
Once or Twice a Month	2842	53.7
Never or Hardly Ever	236	4.5

Write a few sentences about how to solve a mathematics problem

	n = 5,299	%
Almost Every Day	848	16
Once or Twice a Week	1595	30.1
Once or Twice a Month	2083	39.3
Never or Hardly Ever	773	14.6

Discuss solutions to mathematics problems with other children

	n = 5,290	%
Almost Every Day	326	6.2
Once or Twice a Week	789	14.9
Once or Twice a Month	2050	38.8
Never or Hardly Ever	2125	40.2

Work on and discuss mathematics problems that reflect real-life situations

	n=5,284	%
Almost Every Day	162	3.1
Once or Twice a Week	972	18.4
Once or Twice a Month	2364	44.7
Never or Hardly Ever	1786	33.8

Use a computer for math

	n = 5,286	%
No Time	2575	48.7
Half Hour or Less	1469	27.8
About one hour	972	18.4
About two hours	270	5.1

Use visual representations (e.g., diagrams, tables, models)

	n= 5,296	%
Almost Every Day	109	2.1
Once or Twice a Week	1211	22.9
Once or Twice a Month	2600	49.1
Never or Hardly Ever	1376	26.0

Question given: In a typical day, how much time do the children in this child's mathematics class spend in the following activities?

Teacher-directed whole class activities

	n = 5,290	%
No Time	66	1.2
Half Hour or Less	3364	63.3
About one hour	1175	22.1
About two hours	385	7.2
Three Hours or More	323	6.1

Teacher-directed small group activities

	n = 5,241	%
No Time	764	14.4
Half Hour or Less	3663	69.9
About one hour	608	11.6
About two hours	174	3.3
Three Hours or More	32	0.6

Teacher-directed individual activities

	n = 5,220	%
No Time	788	15.1
Half Hour or Less	3703	70.9
About one hour	537	10.3
About two hours	154	3.0
Three Hours or More	38	0.7

Child-selected activities

	n = 5,190	%
No Time	2702	52.1
Half Hour or Less	2254	43.4
About one hour	212	4.1
About two hours	19	0.4
Three Hours or More	3	0.1

Children working in heterogeneous groups

	n = 5,261	%
No Time	765	14.5
Half Hour or Less	3383	64.3
About one hour	855	16.3
About two hours	193	3.7
Three Hours or More	65	1.2

APPENDIX C

Descriptive Statistics: Professional Development

Professional Development: Time Spent in Math Workshop

Number of classes	*n =5,023*	*%*
0	1445	28.8
1	180	3.6
2	377	7.5
3	286	5.7
4	245	4.9
5	247	4.9
6	327	6.5
7 or more	1916	38.1

Professional Development: Usefulness of PD

	n = 3,522	*%*
Not at all Useful	76	2.2
Slightly Useful	570	18.3
Moderately Useful	1522	43.2
Very Useful	1354	38.4

APPENDIX D

Descriptive Statistics: Teacher Backgrounds

Prompt given: Teacher Background Data: Indicate yes or no to the following

Undergraduate Math Education	*n = 5,045*	%
Yes	263	5.2

Undergraduate Mathematics	*n = 5,046*	%
Yes	310	6.1

Certification In Elementary Math	*n = 5,173*	%
Yes	1844	35.6

Certification in Secondary Math	*n = 5,097*	%
Yes	471	9.2

Teacher Education Math Courses

Years		*n = 5,096*	*%*
	0	295	5.8
	1	1313	26
	2	1267	25.1
	3	813	16.1
	4	412	8.1
	5	204	4
	6 or more	752	14.9

Years Taught A Grade

	n = 5,274	%
1	704	13.3
2	654	12.4
3	553	10.5
4	495	9.4
5	421	8
6	318	6
7 or more	2129	40.4

Years Been a School Teacher

	n = 5,281	%
1	187	3.5
2	296	5.6
3	229	4.3
4	283	5.4
5	289	5.5
6	303	5.7
7	250	4.7
8	207	3.9
9 or more	3237	61.4

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